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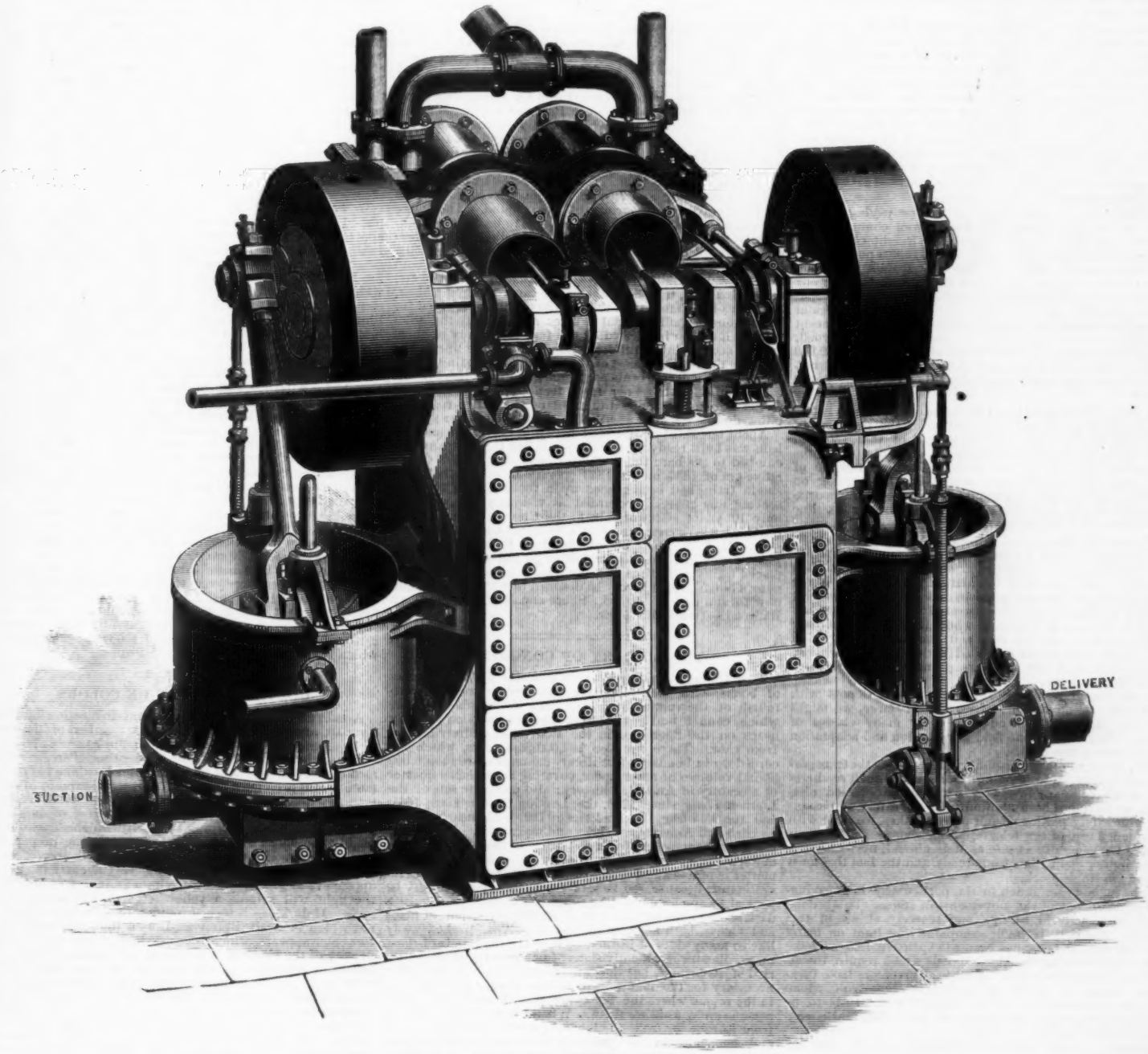
### IMPROVED AIR REFRIGERATING MACHINE.

We illustrate a machine constructed by Messrs. Hall, of Dartford, for use in the Australian meat trade. The engraving is very nearly self-explanatory.

The machine consists of a pair of horizontal trunk engines, mounted on the top of a condenser. To one side is bolted a compressing cylinder, 27 inches diameter and 18 inches stroke. To the other side is bolted the expansion cylinder, 22 inches in diameter and 18 inches stroke; both these cylinders are open-topped. The valves are placed in the bottoms of the cylinders, and are worked by cams on the crank shaft, and levers. Air is drawn into the compressing cylinder on the up stroke, and delivered, on the down stroke, into the surface condenser at a pressure of about 50 lb. to 55 lb. on the square inch. The air here parts with its heat in the condenser, and it is then delivered into the expansion cylinder, the valve of which cuts off at about one-fourth stroke. The expanded air is then delivered through a pipe into the room to be cooled. About fifty per cent. of the work expended in the compressing cylinder is returned in the expansion cylinder, the difference being made up by the engine. The machine is but one of several Messrs. Hall have in hand of different patterns. The outline diagrams show the form which they recommend for ordinary use, the height being kept down to render it specially suitable for use between decks, but the machine can be made to take any form almost, and can be made of any dimensions to suit particular requirements. The condenser, or refrigerator, consists of nests of brass tubes, through which the water circulates. The tubes are of brass, ⅛ inch in diameter outside. The ends of the tubes are accessible through the man-lids shown.—*The Engineer.*




IMPROVED AIR REFRIGERATING MACHINE.

### AMERICAN RAILWAYS.

Going back one year, for purposes of comparison, on the 1st day of January, 1879, we had in the United States, 81,841 miles of railroad, on which there were 101,660 miles of track, or enough to encircle the globe three and a half times. There ran upon these roads 16,445 locomotives, 11,683 passenger cars, 4,413 baggage, mail, and express cars, and 423,013 freight cars.

The capital invested was $4,772,297,349, or $58,915 per mile of railroad; the gross earnings were $490,103,351, or $6,209·53 per mile; the working expenses were 61·79 per cent. of earnings, or $302,528,184—say $3,887.10 per mile of railroad; and the net earnings were $187,575,167—say $2,322.42 per mile, or 3·932 per cent. on the nominal capital.

While the greater cheapness of our American railroads is in some measure due to the comparative smoothness of much of our country, and to the absence of heavy land damages, much more is due to the methods of construction applied to the railroads themselves, to the cheap and efficient expedients which our engineers have introduced, and especially to the character of the rolling stock which we have adopted.

The early locomotives obtained an adhesion and tractile power equal to $\frac{1}{7}$ of the weight upon their driving wheels. I believe that in other countries $\frac{1}{4}$ of the weight is even now considered a standard and satisfactory performance, while our American locomotives, including the latest type, the "Consolidation" engine, of 50 tons weight, regularly work up to $\frac{1}{4}$ in winter, and $\frac{1}{5}$ in summer, of the weight upon their drivers, with occasional performances up to $\frac{1}{3}$, and even less.

That is to say, if a locomotive has 88,000 pounds weight upon eight driving wheels, and obtains an adhesion of $\frac{1}{4}$, it will pull a train equal in resistance to the lifting of a weight of 12,571 pounds; while if it works up to $\frac{1}{3}$ in adhesion, it would pull 19,555 pounds, or 55 per cent. more under the same circumstances.

Not only do our locomotives pull greater trains than do European locomotives, in proportion to their own weight, but they run more miles in the course of the year: Stürmer's statistics for 1875, showing that the average train mileage for locomotives (not the engine mileage, but the mileage of passenger and freight trains, divided by the whole number of locomotives), was for all Europe, 15,720 miles per year, and for the United States, 21,900 miles per annum.

This has been accomplished by a series of improvements in construction, which have brought our locomotives materially to differ from their European prototypes, and which fairly entitle us to speak of them as American in design.

These improvements chiefly consist: First, in the substi-

tution for a rigidly attached pair of leading wheels, of a four-wheeled truck pivoted at its center, or of a swing beam pair of wheels, under the front end, thus allowing lateral play, and giving the engine great ease in passing curves; and, also, second, in the connecting together of the driving wheels and axles, with one or more pairs of equalizing levers, to distribute the weight among them, and thus keep its apportionment nearly constant, while the wheels are free to follow and adapt themselves to all the irregularities and deflections of the track.

These two features, together with careful counterbalancing and easy springs, have not only given our locomotives great ease and steadiness of motion, even over rough tracks, but have made them more efficient over good tracks. Moreover, outside cylinders and accessibility of parts give great facility for repairs, and notwithstanding the higher prices which we pay in this country for labor and materials, our American locomotives are cheaper to build and to maintain than those of foreign makers.

This efficiency in the motive power has enabled us to cheapen greatly the construction of our roads, by locating them with sharper curves and steeper grades than would otherwise be possible, as is evidenced by the comparison of cost per mile already given.

There are, however, a number of features of European locomotive practice which it would be well for us to study, and possibly to imitate, such as improved methods of boiler construction, economy of fuel, and better proportion of heating surfaces.

By calling attention to these, the editors of the *Railroad Gazette*, from whom many of the statistics hereafter to be given have been obtained, are doing the country, as well as engineers, a good service.

We have applied to railroad cars similar features of flexibility and diminished resistance, by placing under each end a pivoted truck of four wheels, instead of a single pair of wheels rigidly attached. This arrangement enables us not only to shorten the wheel base, but to lengthen the car. It passes with ease around curves even as short as 100 feet in radius, and improved design and workmanship, together with our tight journal boxes, lubricated with mineral oils, have reduced the resistance of cars so much, that recent experiments made upon several of our roads, indicate a rolling friction of only 4 or 5 pounds per ton, *on a level straight line at low speed*, or only one-half of the coefficient as given in all engineering note books.

Until recently, the proportion of live or paying weight carried by our freight cars did not as well compare with their own dead weight as in European freight cars. The latter, with four wheels, generally weigh 13,000 pounds, and carry 20,000 pounds when fully loaded. It took us a long while to realize that having started with 8 wheels under our cars, we could, by increasing their weight in some degree, at the same time increase their carrying capacity in still greater ratio, and so obtain better proportions. The more recent freight cars, however, those of the Pennsylvania Railroad, carry 40,000 pounds, and they weigh about 21,000 or 22,000 pounds, if built as box cars, and 19,000 pounds, if constructed as coal cars; the latter especially being exceedingly well designed.

And since I have mentioned the name of the Pennsylvania Railroad, allow me to call the attention of the members of this society to the study and imitation of that splendid work, which, if not the most perfect, is certainly one of the most perfect railroads in the world. The expenditure of money and thought and care which has been going on upon it for many years, has reduced the cost of transportation over it to less than obtains on any other trunk line which crosses the Alleghany range.

There are two features of European practice, which, perhaps, it would be well for us to introduce in our freight cars. The first is the substitution of iron for the wooden sills, which now form their foundation. The second is the larger use of platform and gondola cars for carrying freight. Even dry goods and groceries, covered with tarpaulins, are carried on flat cars in England, where it rains much oftener than it does here; and the ease and cheapness with which these cars are loaded and unloaded (with proper appliances), in comparison with our box cars, promises a notable economy of station labor.

We also continue to handle all goods at our depots with hand labor. At all stations where traffic is large, we might substitute machinery to advantage for many classes of freight. This offers a fine field of invention and adaptation for engineers or mechanics.

While paying much attention to cheapness in the transportation of freight, and obtaining results, as we shall see hereafter, which compare favorably with those obtained elsewhere, we have not been unmindful of the safety of passengers. Our safety platforms and power brakes, together with the extended use of the telegraph, have made traveling in this country generally as safe as it is abroad, notwithstanding the lighter character of our roads, and the fact that most of these are single tracked.

We have, however, much to do, particularly in introducing signals to control the movements of trains. This is done almost universally in Europe, and scarcely at all in this country. Not only is traffic comparatively light on many roads, but with us labor has been so expensive, that we have hesitated at adopting the block signals which require the attendance of numerous men. American inventors have turned their attention instead to automatic signals, of which there are several systems which promise well. It is to be hoped that they will be so improved, perfected, and cheapened as to lead to their adoption

Although our railroads were originally cheaply and imperfectly built, and although we pay in this country a great deal more for labor and material than the prices which obtain in Europe, we have nevertheless reduced the cost of transportation to as low figures, if not lower, than any which obtain on the other side of the ocean. The grindstone of competition between the railroads themselves, and with canal, river, and lake routes, has reduced freight transportation to such a fine point, that our railroad managers have devised new and cheaper methods of doing their work, have learned to operate their roads with a smaller proportion of men, and have accomplished results which astonished even themselves.

It is difficult to make comparisons of rates and costs between different railways, because scarcely any two of them are placed under precisely the same circumstances, but it is known that the lowest rates in England are given on mineral traffic. This is understood to be about $\frac{3}{4}$ of a cent a ton a mile, while the regular rate from Chicago to New York upon domestic produce (grain, flour, provisions, lard, etc.) is now $\frac{1}{2}$ of a cent a ton a mile, and in times of sharp competition has been $\frac{1}{3}$ of a cent a ton a mile.—*O. Chanute.*

## AN ELEVATED ROAD IN 1836.

IT may not be generally known that a determined effort was made to build a railroad substantially on the present line of the Lake Shore and Michigan Southern in Ohio 15 years before the opening of the Cleveland and Toledo, or the Cleveland, Painesville and Ashtabula, now embraced in the Lake Shore and Michigan Southern. The Ohio Railroad Company was organized at a residence in Painesville, in April, 1836, to build a railroad from the Pennsylvania State line, through the northern tier of counties of Ohio to the Maumee River, at Manhattan, then a paper city rival of Toledo, now part of it. In 1829, the year in which Stephenson made his triumphant trial trip with the Rocket, on the Liverpool and Manchester Railway, Col. Clinton, a civil engineer, announced his project for the Great Western Railway from New York to the Mississippi River, a distance of 1,050 miles, at an estimated cost of $15,000,000. Soon after another and a rival project was put forth to build a railroad on piles—10 feet apart, on which were to be placed planks nine by three inches, edgewise, which supplied the tracks. No iron to be used except the bolts and nuts necessary to fasten the planks to the piles. This road—1,050 miles—was to cost less than $1,000,000! Here is the estimate made by the projector.

| | |
|---|---|
| Right of way | $532,800 |
| Lease of mills to saw planks | 1,850 |
| Getting out posts | 31,400 |
| Bolts and nuts | 211,200 |
| Leveling posts and laying rails (planks) | 62,800 |
| Setting posts and piles | 31,400 |
| Sawing | 35,500 |
| Total | $906,950 |

Strange as it may seem, this unique plan, with the addition of a light strap-iron rail, was adopted by the Ohio Railroad Company.

In 1836 the route east of Cleveland was surveyed and located. Then the directors, possibly influenced by private interests, quarreled as to where to begin the work. One party insisted that the section between Fremont and the Maumee River be constructed first, while another as strenuously insisted on beginning at Cleveland, and proceeding eastward. The former plan prevailed, and the first pile was driven at Fremont, near the present Lake Shore and Michigan Southern station, June 16, 1839. The piles or posts were 12 to 16 inches in diameter, and 7 to 28 feet long, to accommodate the inequalities in the surface of the ground. They were driven 10 feet apart, and as the road was to be double track, there were four rows, or 2,112 piles per mile. Upon these piles were placed longitudinally chestnut planks or sills. Then came the crossties, 6 feet apart, requiring for both tracks 1,760 per mile. On these were placed the stringers, or wooden rails, 8 by 8. Last of all came the iron ribbon, for it was little more than that, as the estimate provided for but 25 tons per mile of double track road. That the piles were well driven is attested by the fact that many of them may be seen to-day at different points along the line. The prices in the estimated cost of the road are interesting: Iron, $80 per ton; spikes, 9 cents per pound; white oak ties 20 cents each; timber, $7 to $8 per 1,000 feet. The chief engineer, Cyrus Williams, estimated the cost of the entire road, 157 miles, double track, at $2,653,676, about $16,000 per mile.

About one third of the road between Cleveland and Toledo was built ready for the strap rail, but the company succumbed to the hard times which followed the wild speculative era of 1836, and in 1843 operations ceased before a single train had been placed upon the track. The whole scheme was generally regarded as visionary and wild, yet only 10 years afterward (1853) the Cleveland and Toledo Railroad was opened, and was a brilliant success from the start. Had the directors of the Ohio Railroad Company pushed on a little further, laid 40 or 50 miles of track, and placed trains on it, thus forming a basis for selling the company's bonds, it can hardly be doubted that their road would now form a part of the Lake Shore and Michigan Southern Railroad.—*Cleveland Leader.*

## THE LIBRARY OF CONGRESS.

THE Library of Congress now contains 375,000 volumes of books, with shelf-room for only 280,000, so that one-fourth of the volumes are practically inaccessible. Those which cannot find places on the shelves are piled in dusty heaps on the floor and in the alcoves, or entirely hidden from view. There are also 120,000 pamphlets, which are corded up in bundles. The library contains more than 6,000 bound volumes of newspapers, covering more than a quarter of a century of American history; also complete sets of the London *Times* since 1796, the London *Gazette* since 1665, and the *Moniteur Universel* since 1789, with nearly all the English and American reviews and magazines. Each State has been represented for many years in the library by two newspapers, one of each political party. All this valuable matter is practically beyond the reach of the student and investigator, because, for lack of room, these papers must be packed away obscurely, like rubbish in a storehouse. In a dark room in the loft lies a remarkable collection of maps and charts, both manuscript and engraved, packed away like so many sides of leather. There are thousands of these maps, illustrating the divisions of our country at every period of its history, but they are inaccessible. All the labor necessary for the maintenance of the library must be done in the rooms where the books are placed, and where many persons are consulting them. When a box of books arrives from Europe or from the binder's, it must be broken open and unpacked in the public halls of the library, because there is no other room provided for such work. So crowded is every foot of space, and so many are the duties which must be performed under the eyes and almost under the feet of visitors and readers, that there are no places for quiet consultation and literary labor, such as every great library ought to possess. The librarian not only superintends the business of a library which is the tenth in the world's list as regards size, but he also preserves the records of copyright, and receives two copies of each copyrighted publication. During last year 18,000 copyright entries were made. Under the copyright law an immense number of prints, engravings, chromos, photographs, and the like, have been received, and out of these a very interesting and instructive collection might be made for exhibiting the progress of the arts of design in America. But they cannot be seen; they lie in heaps, with their stamps upon them Even the copyright records, from the first enactment of the law in 1790, including the original records of more than forty United States District Clerk's offices, are stored away in a dark cellar, where constant reference is made to them with great difficulty.

After recounting these facts, with reference to the recent debate in Congress touching the erection of proper quarters for the books, the *Times* Washington correspondent goes on to sketch the history of the library as follows:

"The Library of Congress was founded in 1800, when the seat of government was transferred from Philadelphia to this city. There were less than five hundred inhabitants in this place then, and $5,000 was appropriated with which to buy such books as Congress might need. There were not then in this country more than three public libraries of more than 5,000 volumes each. In 1801 and 1802 there were warm debates in Congress upon propositions for appropriating money for making additions to the library. Mr. Bayard, of Delaware, advocated an appropriation of $1,000 per year; Mr. Bacon, of Massachusetts, moved to make the sum $10,000 per year, and John Randolph, of Virginia, declared that either of these propositions was extravagant. At last an act was passed by which $3,800 became available for books, but no librarian was appointed until 1815. Since that time there have been four gentlemen in that position. George Watterson served fourteen years, John S. Meehan thirty-two years, John G. Stephenson three years, and Ainsworth R. Spofford has now occupied the place for sixteen years. In 1814 the library contained but 3,000 volumes, and these the British burned on August 24 of that year. The Congress which convened in special session in September, 1814, had no library, but ex-President Jefferson offered to Congress at its own price a collection which he had been gathering during fifty years with great care. The Senate at once passed a bill for the purchase of this library, but there was sturdy opposition in the House. Some said Mr. Jefferson's collection was larger than Congress required. Some thought the books would cost too much, and some objected to the philosophical character of many of the volumes. Mr. King, of Massachusetts, moved an amendment directing the committee to select from the library, after its purchase, "all books of an atheistical, irreligious, and immoral tendency, if any such there be," and send them back to Mr. Jefferson at Monticello. This amendment was rejected, and the bill was passed by a vote of eighty-one to seventy-one. The character of this discussion has a singular interest to the reader of to-day. It is said that Jefferson's library was one of the best private selections which had been made at that time, and that in no other way than by its purchase could Congress have secured so valuable and comprehensive a library of reference.

It was not until 1824 that the Library of Congress was placed in its present location; and at that time the annual appropriation for new books was increased to $5,000. In 1851, when another fire came, there had been gathered but 55,000 volumes, and of these the flames spared 20,000. This fire induced Congress to pay to the library the attention which it deserved; $85,000 was appropriated for the purchase of books, and $72,500 for repairing and restoring the library-room. From that time the development of the library was symmetrical; in 1865 additions to the building were constructed which afforded room for 150,000 volumes; in 1866 the Smithsonian library of scientific works was acquired; in 1867 the Peter Force historical collection was bought for $100,000, and in 1870 the enactment of a new copyright law established a source of constantly-increasing annual additions. When Mr. Spofford became librarian, in 1864, there were in the library 86,414 volumes; now there are more than 375,000. It is well known that Mr. Spofford is a librarian of rare ability, and it was truly said in the Senate a few days ago that but for his services the utility of the library as a place of resort for information would be almost wholly destroyed by difficulties which other librarians seldom encounter. In sixteen years the collection has more than quadrupled in size, and has become the tenth in size of the world's libraries. Ten years ago there were forty-two European libraries which were larger. It is estimated by those who have carefully examined the subject, that when sixteen more years shall have passed, the volumes in this library will number 2,250,000, and that it will be surpassed in extent only by the National Library in Paris and the British Museum. Of these the first now contains 2,000,000 volumes, and the second 1,150,000, accumulations which it has taken centuries to build up.

## GOETHE'S THEORY OF COLORS.

A LECTURE delivered at the Royal Institution by Prof. Tyndall, and published in the current number of the *Fortnightly Review*, revives an interest in Goethe's theory of colors, which, although it has been for a long time disregarded by men of science, was said by Sir Charles Eastlake to contain more useful principles in all that relates to harmony of color than any that have been derived from the established doctrine. Color, according to Goethe, is a degree of darkness, a *lumen opacatum*, something so allied with shadow as to be readily combined with it, so that shadow is the proper element of color. By this theory the highest degree of light when seen through a medium but very slightly thickened appears to us *yellow*. If the medium be increased in density the light will assume a yellow-red hue, which deepens to *ruby*. If darkness is seen through a semi-transparent medium which is itself illuminated by a light striking on it, a *blue* color appears, which becomes lighter and paler as the density of the medium is increased, but appears darker and deeper in proportion as the medium becomes transparent. "We see," says he, "on one side light, brightness, on the other darkness, obscurity; we bring the semi-transparent medium between the two, and from these contrasts and this medium the colors develop themselves, contrasted, in like manner, but soon, through a reciprocal relation, directly leading again to a point of union." Goethe's earliest experiment, which led him so hastily to the conclusion that Newton's theory of color was wrong, says Prof. Tyndall, consisted in looking through a prism at the white wall of his own room. He expected to see the whole wall covered with colors, this being, he thought, implied in the theory of Newton. But to his astonishment it remained white, and only when he came to the boundary of a dark or bright space did the colors reveal themselves. This question of "boundaries" is one of supreme importance to the author of the "Farbenlehre," the end and aim of his theory being to account for the colored fringes produced at the edges of his refracted images. As before intimated, darkness, according to Goethe, had as much to do as light with the production of color. Color was really due to the commingling of both. Not only did his white rectangles upon a black ground yield the colored fringes, but his black rectangles on a white ground did the same. The order of the colors, however, seemed different in the two cases. Both these effects are deducible from Newton's theory of colors. But this, though explained to him by physicists of great experience and repu-

tation, Goethe could never be brought to see, and he continued to affirm to the end of his life that the results were utterly irreconcilable with the theory of Newton. In his own explanations, Goethe began at the wrong end, inverting the true order of thought, and trying to make the outcome of theory its foundation. Apart from theory, however, his observations are of great interest and variety. He looked to the zenith at midnight, and found before him the blackness of space, while in daylight he saw the blue firmament overhead, and he rightly adopted the conclusion that this coloring of the sky was due to the shining of the sun upon a turbid medium with darkness behind. He by no means understood the physical action of turbid media, but he made a great variety of experiments bearing upon this point.

Water, for example, rendered turbid by varnish, soap, or milk, and having a black ground behind it, always appeared blue when shone upon by white light. When, instead of a black background, a bright one was placed behind, so that the light shone, not *on*, but *through*, the turbid liquid, the blue color disappeared, and he had yellow in its place. Such experiments are capable of endless variation. To this class of effects belongs the painter's "chill." A cold bluish bloom, like that of a plum, is sometimes observed to cover the browns of a varnished picture. This is due to a want of optical continuity in the varnish. Instead of being a coherent layer it is broken up into particles of microscopic smallness, which virtually constitute a turbid medium and sends blue light to the eye. This question of turbid media took entire possession of the poet's mind. It was ever present to his observation. It was illustrated by the azure of noon-day, and by the daffodil and crimson of the evening sky. But how in the production of the spectrum do turbid media come into play? If they exist, where are they? If you place a white card near the surface of a piece of plate glass, and look obliquely at the image of the card reflected from the two surfaces, you observe two images, which are hazy at the edges and more dense and defined where they overlap. These hazy edges Goethe pressed into his service as turbid media. He fancied that they associated themselves indissolubly with his refracted rectangles—that in every case the image of the rectangle was accompanied by a secondary hazy image, a little in advance of the principal face. At one edge, he contended, the advanced secondary image had black behind it, which was converted into blue; while at the other edge it had white behind it, and appeared yellow. When the refracted rectangle is made very narrow the fringes approach each other, and finally overlap. Blue thus mingles with yellow, and the green of the spectrum is the consequence. This is, in a nutshell, his theory of colors. The fact is, that between double images and turbid media there is no kinship whatever. Turbidity is due to diffusion, in a transparent medium, of minute particles having a refractive index different from that of the medium. But the act of reflection which produced the penumbral surfaces, whose aid Gothe invoked, did not charge them with such discrete particles.

With regard to the production of the green of the spectrum by the overlapping of yellow and blue, Goethe, like a multitude of others, confounded the mixture of blue and yellow lights with that of blue and yellow pigments. This was an error which is shared by the world at large. But in Goethe's own day, Wünsch, of Leipsig, had corrected the error, and proved the mixture of yellow and blue lights to produce white. Any doubt that might be entertained of Wünsch's experiments is entirely removed by the experiments of Helmholtz and others in our own day. Thus, to sum up, Goethe's theory, if such it may be called, proves incompetent to account even approximately for the Newtonian spectrum. He refers it to turbid media, but no such media come into play. He fails to account for the passage of yellow into red and of blue into violet, while his attempt to deduce the green of the spectrum from the mixture of yellow and blue is contradicted by facts which were extant in his own time.

## MUSICAL PITCH.

A PAPER was read before the American Association "On the Present Condition of Musical Pitch in Boston and Vicinity," by Charles R. Cross and Wm. T. Miller. The essay recounts an extensive series of experiments carried on during the spring of 1880 at the Massachusetts Institute of Technology, in order to determine the amount of variation among the standard pitches in use by different makers of musical instruments in the neighborhood of Boston. It opens with a description of the construction and use of the two tuning fork tonometers used, one of which is a tonometer with equal differences, the other a tonometer with unequal differences, in the pitch of the forks composing it. The results of the measurements are given in the following table, which is here presented in an abbreviated form:

| No. | Designation. | No. of Vibrations. C3. |
|---|---|---|
| 1. | Koenig, physical pitch | 256·1 |
| 2. | Koenig, French pitch (approximate) | 260·2 |
| 3. | Koenig, German pitch | 264·2 |
| 4. | Ritchie, physical pitch. | 256·2 |
| 5. | Koenig, physical pitch | 256·2 |
| 6. | Marlaye, physical pitch | 256·4 |
| 7. | Ritchie | 259·1 |
| 8. | Ritchie | 259·4 |
| 9. | Ritchie, copy of Chickering's standard. | 269·0 |
| 10. | Mason & Hamlin, French pitch (not used at present) | 259·1 |
| 11. | Hutchings, Plaisted & Co | 264·0 |
| 12. | Hook & Hastings, old flat organ pitch. 69° F. | 264·6 |
| 13. | Organ in Church of Immaculate Conception, Boston | 266·7 |
| 14. | Smith American Organ Company | 268·2 |
| 16. | Chickering's standard fork | 268·5 |
| 17. | H. F. Miller's pianos | 268·9 |
| 18. | Mason & Hamlin, present standard pitch | 269·0 |
| 19. | Fork of W. H. Clement, tuner | 269·2 |
| 20. | George Wood & Co., cabinet organs | 269·5 |
| 21. | Hook & Hastings, present standard pitch, 73° F. | 270 0 |
| 22. | Chickering piano, as used at Joseffy concerts, Boston, 1880 | 270·1 |
| 23. | Covent Garden pitch, 1879 | 270·3 |
| 24. | Weber's pianos | 270 3 |
| 25. | Thomas's pitch | 271·1 |
| 26. | Music Hall organ, 70° | 271·2 |
| 27. | Steinway's pitch | 272·2 |
| 28. | Highest New York pitch | 273·9 A3. |
| 29. | Nicnols's fork (Germania orchestra) Boston | 448 |
| 30. | Marlaye's A fork | 426 |
| 31. | Florence pitch, Marlaye, 1845-50 | 438 |
| 32. | Vienna pitch, Marlaye, 1845-50 | 446 |
| 33. | Milan pitch, Marlaye, 1845-50 | 448 |

The table embodies the results of a great number of separate measurements, which cannot probably be relied upon in most cases to within a tenth of a vibration. It will be seen that the lowest pitch used in the city at present is substantially identical with the German (Stuttgart) pitch. (See Nos. 3, 11, 12.) The standard pitch of the Chickerings and that of H. F. Miller are about four vibrations sharper (Nos. 16, 17); Mason & Hamlin's is the same; George Woods & Co.'s a little sharper, while the present pitch of Hook & Hasting's is sharper still, though lower than that of the Music Hall organ. The Steinways' pitch is the highest noted, except the high New York orchestral pitch (9 P.M.) No. 28. A somewhat detailed historical sketch of the different standards of pitch now used by our musical instrument makers was then given. A fork is generally employed as a standard, though a few makers use a reed or a pipe; but a number of the forks have their pitch determined from the note of the oboe, which is erroneously supposed by many musicians to be constant in pitch. The pitches of a number of the church organs in the city were also given. Among those tuned to the old flat pitch formerly used by Messrs. Hook & Hastings are those in the following churches: St. Paul's (built in 1854), Church of the Unity (1859), Berkeley Street (1861), Christ Church (1861), Arlington Street (1861), Emmanuel (1862). Also at a low pitch are the organs in St. John's Church, Roxbury; the Old South Church, Boston; All Saints' Church, Worcester, built by the Messrs. Hutchings, Plaisted & Co. At a higher pitch is the organ in the Church of the Immaculate Conception in this city, built by Hook & Hastings; and still sharper are the organs in Mechanics' Hall, Worcester, the South Congregational Church, Boston, the Plymouth Church, Brooklyn, the Cathedral, Boston, and the great Cincinnati organ, built by the same makers, as well as the organ in the Music Hall of Boston. Hence at present there are at least two distinct pitches used in the city, and formerly, when the Music Hall organ was tuned to the French pitch, there were three. The marked sharpness of our present pitch when compared with that of Handel, Mozart, and Weber was discussed, and its retention deprecated. Upon these facts followed a discussion of certain physical phenomena observed in tuning forks from one another, and the influence of these upon a rise in pitch. After some criticisms upon the use of the oboe as a standard the essay discussed the origin of the erroneous opinion frequent among musicians as to the liability of tuning forks to variation, and concluded with a reference to the unscientific method of tuning orchestra and organ or piano upon a system of equal temperament, but with different notes, as a basis in the two classes of instruments.

## RESERVOIR BLOWPIPE.

By LIEUT.-COLONEL W. A. ROSS.

THE reservoir "blowpipe," which I would respectfully submit, should now be called "pyrogene," leaving the other ridiculous term to be applied to boys' peashooters or the tinker's soldering pipe, enables one to blow almost for ever (if required, but I deprecate so much zeal as that expression implies) without feeling the least fatigue in the cheek muscles, more especially if a trumpet mouthpiece be used, as the reservoir not only sends sufficient blast for a jet with large orifice, but forces air back into the cheeks, keeping them distended, so that all the operator has to do is to keep up a fresh supply, and it seems to me that any one will be able to use this pyrogene at first trial, without learning for two or three days, as is necessary with the ordinary kind. The operator should possess two or three elastic bags of differing *thickness* to suit his powers of blowing.

Thus the traveler need not take a hand-blower with him, as the blast from this is quite as powerful, and he can perform the boric-acid operations with ease by means of it; besides which, when packed, it only takes up the room of a single tube, as shown in Fig. A[1]. I have declined to patent this invention, wishing that the poorest people of all countries may benefit by it. The jet tube, as will be seen by the sketch, passes right through the lower part of the mouth tube, in which it must, of course, fit air-tight.

References to sketch.—A, reservoir, mouth-pyrogene or blowpipe. B, pyrological candle. C, pyrological burner with two aluminum capsules and boiling water. D, forceps holding platinum wire and bead of boric acid.

Instead of one zinc collar there are now six or seven, of the ordinary thickness, passing entirely up the candle, the lowest one carrying a zinc or (preferably) aluminum tray. Rich people may have the whole apparatus made of thick aluminum, which, from its high powers of conduction, would leave zinc far behind, and constitute (as I believe) a blowpipe lamp unequaled for efficiency and portability combined.

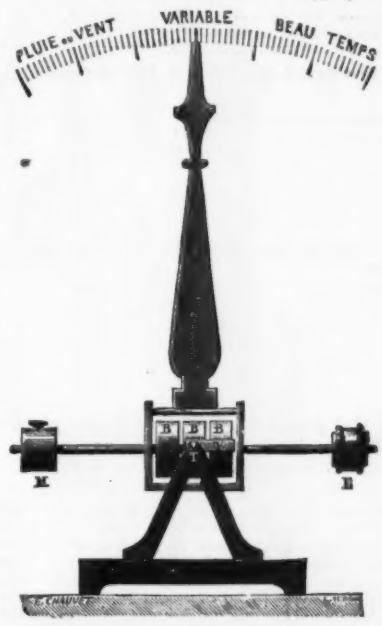
The collars are taken off as the wick burns lower, and it is cut and trimmed with a pair of scissors, but any kind of fat or grease may be added as fuel at top.

Instead of a round brass ring, as shown lately in the E. M., an oblong one is used, so that two capsules of water may be kept hot at different temperatures, the lower one near O P being always boiling; or one capsule may be passed to either position, while the pyrocone is in action.

For the sake of cheapness the whole is made of one brass wire, passing up and down a brass tube, with a piece of thicker wire acting as a clamping screw. The pressure of the blast from the "reservoir pyrogene" may be increased almost to any extent by pressing the inflated bag with the wrist of the right hand holding the pyrogene against the edge of the table.—*English Mechanic.*

## REDIER'S BAROMETRIC BALANCE.

M. REDIER, of Paris, has for a short time past been constructing a sort of barometric balance which bears considerable analogy with Dufour's thermometer. This apparatus, represented in the annexed figure, from *La Nature*, has the advantage of moving a very large index needle—of from thirty to sixty centimeters radius—which can be seen from a great distance. B B B are three aneroid barometer cases. To the first case to the left is attached a frame which carries the counterpoises, M and E. On the same frame is fixed the large index needle. The whole thing pivots on a knife-blade, T, and the counterpoises, M and E, being movable, the apparatus can be balanced in such a way as to cause



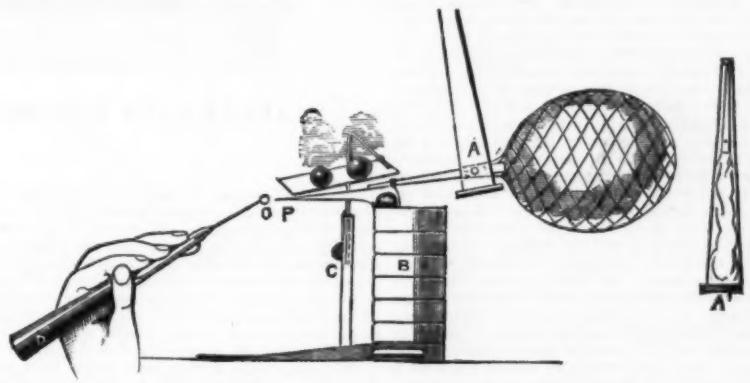

REDIER'S BAROMETRIC BALANCE.

the index to point to any division desired. The cases are attached to a second frame, V. When the pressure increases, these cases are depressed and the two counterpoises move toward the right. The equilibrium is thus broken and the needle moves toward the same side. When the pressure diminishes the contrary effect is produced, and the needle moves to the left.

This lays no claim to being an instrument of precision, but only a very sensitive apparatus which shows at great distances, without any mechanism, the rising or falling atmospheric pressure.

## SOME SCIENTIFIC RESULTS OBTAINED IN THE EIGHTEENTH CENTURY.

THESE pages would fail me were I to attempt to relate in detail the many minor scientific subjects that occupied the attention of the eighteenth century—




IMPROVED RESERVOIR BLOW PIPE.

if, indeed, minor they can be called: how the predicted return of Halley's comet struck every one with wonder; how La Caille was sent to the Cape of Good Hope to determine the parallax of Mars, and make a catalogue of southern stars; how Bode published his celebrated law, which led to the discovery of the asteroids; how Bouguer in Peru and Maskelyne in Scotland determined the attraction of mountain masses, and how from those results Hutton (1778) computed the mean density of the earth, making it 4·5 times that of water; how Cook's first voyage was undertaken in 1769 partly for the observation of the transit of Venus, and partly for the exploration of the Pacific Ocean; how the measurement of time was rendered precise by Graham's invention of the mercurial pendulum and Harrison's invention of the gridiron; how the more exact determination of terrestrial longitude was accomplished both by observations on the place of the moon, and by the transport of time; how the British government paid to the heirs of Mayer a reward of £15,000 for his tables, and to Harrison £100,000 for his marine chronometer; how the reflecting quadrant—that all-important instrument in navigation—was invented by Godfrey; how the disputes respecting the figure of the earth were attempted to be settled by expeditions to Lapland and Peru. Conspicuous among the inventions of the age were the exquisite engines for correctly dividing or graduating instruments for the measurement of angles. The

century that had closed in the direction of physical research with the pile of Volta, closed in the astronomical with the *Mecanique Celeste* of Laplace.—*Dr. John W. Draper, in Harper's Magazine.*

## VELOCITY OF FOWLING PIECE SHOT.

As a result of laborious and scientific experiments, Professor Mayer, in his paper on this subject before the American Association, presented the following tables:

I. 10 Colt gun, 5 drs. Curtis & Harvey powder, 1¼ oz. shot.

| Size of shot. | Vel. at 30 yds. | Vel. 40 yds. | Vel. 50 yds. |
|---|---|---|---|
| No. 1 buck | 1,147 | 1,132 | — |
| FF | 1,146 | 1,126 | — |
| BB | 1,153 | 1,067 | — |
| No. 3 | 1,066 | 1,015 | 928 |
| 6 | 1,012 | 963 | 859 |
| 8 | 995 | 890 | 775 |
| 10 | 908 | 803 | 716 |

II. 10 Colt gun, 4 drs. Curtis & Harvey powder, 1¼ oz. of shot.

| | | | |
|---|---|---|---|
| No. 1 buck | 1,067 | 1,018 | — |
| FF | 1,017 | 1,009 | 967 |
| BB | 1,000 | 967 | 897 |
| No. 3 | 989 | 911 | 872 |
| 6 | 966 | 883 | 806 |
| 8 | 920 | 874 | 776 |
| 10 | 848 | 756 | 669 |

III. 12 Colt gun, 3¼ drs. Curtis & Harvey powder, 1⅛ oz. of shot.

| | | | |
|---|---|---|---|
| No. 1 buck | — | 703 | — |
| FF | — | — | 706 |
| BB | 862 | 795 | 667 |
| No. 3 | 844 | 754 | 696 |
| 6 | 825 | 739 | 600 |
| 8 | 813 | 749 | 607 |
| 10 | 796 | 680 | 610 |

IV. 12 Colt gun, 4 drs. Curtis and Harvey powder, 1¼ oz. of shot.

| | | | |
|---|---|---|---|
| 8 | 847 | 722 | 671 |
| 10 | 748 | 657 | 596 |

A glance at these tables at once shows the rapid increase in the velocity of gunshot from No. 10 up to No. 3. With the heavier pellets the increase in velocity is less marked. Thus, the table headed "12 Colt gun, 4 drs. Curtis & Harvey, 1¼ oz. shot," shows that No. 8 shot has 71 feet per second velocity over No. 10 shot, and No. 6 has 47 feet over No. 8, while No. 3 has only 23 feet over No. 6, and BB shot gains only 11 feet over No. 3. The relations between velocity and weight of pellet shown in this table may be taken as a type of all the experiments, and I have projected them into the accompanying curve, the units of whose axis of abscisse are units of weight, and the units on the axis of ordinates equal four feet of flight of pellet. The next fact, and an important one to sportsmen, which is shown by these experiments is this: If the same charges of powder and shot (4 drs. powder and 1¼ oz. shot) be fired from a 10 gauge and from a 12 gauge gun we get a velocity of 100 per second in favor of the 10 gauge. This is conclusively shown in the comparison of the figures in the tables headed "10 Colt gun, 4 drs. C. &. H., and 12 Colt gun, 4 drs. C. & H., 1¼ oz. shot." With No. 10 shot the mean velocity over the first 30 yards given by the 10 gauge gun is 848 feet; with the same shot and charge in the 12 gauge the velocity is 748 feet, a difference of 100 feet in favor of gauge No. 10. With No. 8 shot the difference is 72 feet. The average difference in favor of the 10 gauge in the flight of No. 8 and 10 shot over 40 yards and 50 yards amounts to 110 feet. I trust that these results will show to sportsmen and the makers of guns that the recent movement in favor of small bore guns is one in the wrong direction. If any gunmaker will make a 10 or even an 8 gauge gun, weighing about 7½ pounds, the sportsman will have the best fowling piece for upland shooting. The reason why a 10 gauge shows such superiority over a 12 gauge is that the same charge of powder and shot occupies less *length* in a 10 than in a 12 gauge, hence there are fewer pellets of shot in contact with the barrel of the 10 gauge to oppose by their friction the projectile force of the powder, and, secondly, the powder in a 10 gauge gun is exploded nearer to the center of its volume, and thus the powder first exploded does not have so much chance of blasting before the unburnt powder contained in the charge removed from the point of ignition. I also venture to predict that, with the same weight of barrels, the 10 gauge will not heat as much as the 12, because the motion of the shot lost by the greater resistance it opposes in a 12 gauge cartridge must appear in the form of heat. The third fact which these experiments show is that the proper charge of shot in a 12 gauge gun for upland shooting is 1⅛ oz., and not 1¼ oz. as has of late years been the practice to use; for the tables show that with 1⅛ oz. of shot and 3¼ drs. of powder an average velocity is obtained, which requires 4 drs. of powder to give to 1¼ of shot a velocity equal to that given by 3¼ drs. to 1¼ oz. Now 4 drs. of powder, if not fired from a gun weighing at least 9 lb., and from a good strong muscular shoulder, is disagreeable. The effect on the body, and especially on the brain, is neither conducive to pleasant or good shooting. The number of pellets in a charge of 1¼ oz. of No. 8 shot is 490. In a charge of 1⅛ oz. of the same shot there are 449, therefore only 50 pellets more in a charge of 1¼ oz. than in a charge of 1⅛ oz., and surely the want of the 50 will not cause a good shot to miss his bird with 449 pellets, nor will the addition of the 50 give a bad shot any more chance of bringing his bird to bag with his 449 pellets.

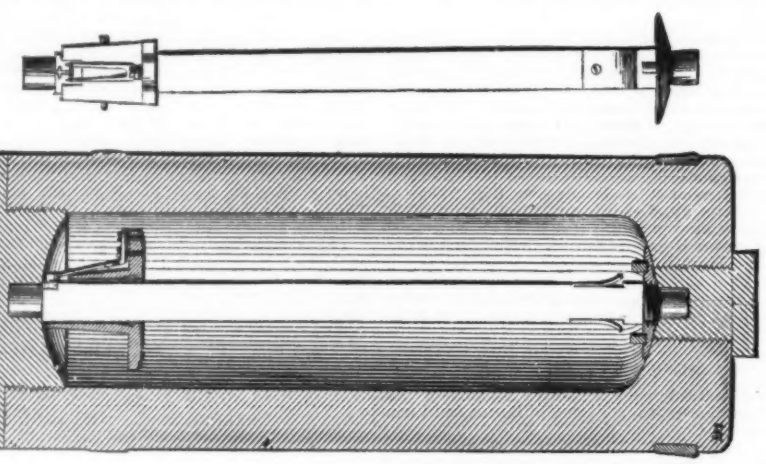
I wish now to show to the association, and especially to those members of it who are sportsmen, other applications of these experiments to the art of shooting on the wing. There are two styles of shooting on the wing. One is called "snap shooting," when the shooter, on selecting the bird which he wishes to bag, quietly brings the gun to his shoulder, and at the instant it is in place fires. If the bird is a cross-shot, he determines at the moment of fire the distance to which he should direct his gun ahead of its flight, this distance depending on the velocity of the bird's flight and on his distance from it. This manner of shooting is practiced the more generally by upland gunners in shooting quail, grouse, and woodcock. The other style of shooting may be designated as "the swing shot," in which the gunner swings his gun ahead of the cross flight of the bird till he attains the proper distance ahead of it, and then fires, but keeps his gun moving with a regular angular velocity till even after its discharge. This method of shooting is, in my opinion, and from my experience, the proper method; and is certainly the only one which has been found successful with shooting of bay fowl—as ducks, brant, and wild geese. Yet there are sportsmen who will contend that they merely follow the bird with the gun, and discharge it while it is pointing at the bird. I put this opinion to the test this summer in the following manner: Four willets came over the decoys, flying in line with a good speed. With my gun I followed the first bird, coolly and accurately, and kept the gun moving regularly after its discharge. Instead of killing the first bird, the third from the leader dropped dead. To give a rule applicable to all gunners as to the distance at which a gun should be pointed ahead of a bird, is not possible. Some sportsmen follow a bird, and then, after reaching before it the proper distance, suddenly stop the angular motion of the gun and then fire. Others after following the bird a short distance give a quick lateral motion to the gun and then fire. Others, again, bring the gun with a lateral motion ahead of the bird, and keep the gun moving till their experience decides the proper distance ahead of its flight, and then fire while the gun is keeping its previous regular velocity. For the simple illustration of the bearing of these experiments on the art of shooting on the wing. I will suppose that at the moment of fire the gun is stationary; in other words, that we are firing "snap shots." If the bird has a velocity across the line of flight of 30 miles an hour, and we are using charges in a 12 gauge gun of 3¼ drs. of Curtis & Harvey powder and 1⅛ oz. shot, we will have to shoot about 5 feet ahead of the bird if it is flying at a distance of 30 yards, at 7 feet ahead if at a distance of 40 yards, and 11 feet ahead of the bird if at a distance of 50 yards. These distances ahead for cross shots at birds flying at the rate of 30 miles an hour may appear out of all reason with the experience of many sportsmen; yet if you will place a stick 5 feet long at 40 yards and ask the same gunners if they would hold ahead of a bird by that distance if it were going with a velocity of thirty miles, I venture to say, from my experiments with them, that they will say, "Of course, that is only about 18 inches;" so difficult is it to determine a length at a distance while sighting along the barrel of a gun. I will conclude with the remark that this paper will not make a good shot on the wing, no more than a description of how to perform on the violin will make an accomplished violinist. It has been said, perhaps rather strongly, that a "pedagogue can teach to read and write, but a crack shot is the gift of the gods."

## APPARATUS FOR REGISTERING THE LAWS OF MOTION OF PROJECTILES.

FOR a long time a means has been sought to determine the laws of motion of a projectile in the bore of a cannon, in order to deduce therefrom the law of the pressures developed by the combustion of the charge, and a knowledge of which would permit of improvement being made in the construction and method of manufacture of cannons, and in the use of gunpowders. M. Sebert, by a new method, has recently succeeded in ascertaining these laws by means of a mechanism placed in the interior of the projectile, and which automatically registers the spaces passed over during a long series of successive times, each equal to a very small fraction of a second—as small even as $\frac{1}{5000}$th. The apparatus, shown in the annexed cut, is very simple, and consists of a metallic rod of square section fixed in the axis of a hollow projectile, and which serves as a guide to a movable mass. This mass or runner carries a small tuning fork, the prongs of which terminate in two small metallic pens which leave undulatory traces of their passage on one of the faces of the rod, which, for this purpose, has been coated with lamp black.

Before the discharge the runner is placed in the front part of the projectile, and the prongs of the tuning fork are kept apart by a small wedge which is affixed to the rod. At the moment the gun is discharged, the runner, on account of its inertia, tends to remain in place, while the projectile is suddenly displaced, carrying the rod along with it, removing the wedge, and thus setting the tuning fork in vibration. The points on the tuning fork then trace on the lamp black two symmetrical sinuous curves. The median axis of these curves is first traced on the lamp black, before the discharge, by sliding the runner by hand along the rod, taking care to leave the tuning fork at rest. The intersections of any one of these curves with the corresponding median line show the relative positions of the projectile and the inert mass at the end of each of the intervals of equal times which the vibrations of the tuning fork represent. It can be easily shown that, owing to the very great velocity imparted to the projectile, the displacement in space of the inert mass through friction and passive resistances, which tend to carry it forward with the projectile, is such as may be quite neglected. So that the relative motion of the mass recorded by the tuning fork may be considered exactly equal and opposite to the motion of the projectile.

The whole mechanism is arranged so that it can revolve around the axis of the central rod, the ends of which are provided with trunnions. Consequently, it does not partake of the rotatory motion imparted to the projectile by the rifling of the gun, and thus are avoided the disturbing effects which would follow such rotation. On supposing known the passive resistances due to the rifling and to the pressure in the bore (which may be deduced by special experimentation), the law of the pressures developed by the gases from the powder on the base of projectiles can then be determined by this process. It is evident that the motion of a projectile as it buries itself in sand or other resistant medium, can be determined in a similar way.



APPARATUS FOR MEASURING THE LAWS OF MOTION OF PROJECTILES.

## THE PRESENTATION OF SONOROUS VIBRATIONS BY MEANS OF A REVOLVING LANTERN.

By HENRY CARMICHAEL, Ph.D., Göttingen.

AT the meeting of the American Association for the Advancement of Science, at Hartford, in 1874, a paper was read by the author on "A New Method for the Presentation of Sound Waves," in which was described the arrangement represented in Fig. 1.

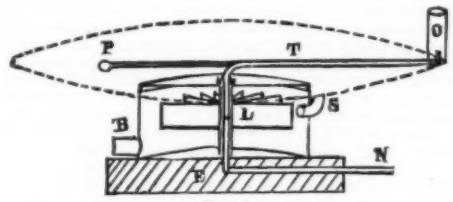



FIG. 1.

The principal novelty of this consists in a small lantern containing a coal-gas flame connected with a König's manometric capsule, the upright lantern being so placed at the end of a horizontal arm that it could be rapidly revolved in the horizontal plane.

The frequent destruction of the glass cylinder forming the lantern led to the advantageous substitution of a mica cylinder. The cylinder, O, is open at both ends, and on being slightly inclined backward from the vertical of the plane of revolution it effectually screens the flame which would be otherwise immediately extinguished.

The lantern arm, T, is bent in to the vertical axis of revolution, and by an enlargement at this place it is made to slip over and form a gas-tight joint with the right-angled tube, N, which is firmly fastened in the base block, E. The rotation of the lantern is conveniently maintained by a small water wheel, L, attached to the vertical shaft. The water enters the case at S and escapes at B. That the lantern may run smoothly, the moment of the lantern, O, is counteracted by the adjustable weight, P.

Flexible tubing connects N with König's manometric capsule. When no sound enters the capsule a smooth band of light appears, which, on the introduction of sound, is broken into a series of teeth, large or small, simple or compound, according to the nature of the sound. The peculiarities of this flame band can be seen from the most distant parts of an audience room.

Although the performance of this instrument was highly satisfactory, it was exceeded in the following modification (Fig. 2), which, though hitherto unpublished, has been publicly used by me during the last three years.

The advantages of a sensitive flame, which is made to revolve in the vertical plane, must be obvious. Not only are all the teeth representing the sound waves brought within the field of vision, and the foreshortening of the teeth upon either side avoided, but by the introduction of oxygen into the lantern the brilliancy of the flame is greatly increased. It is important that the lantern and other moving parts be made as light as possible. The thin mica cover of the lantern is conveniently brought into shape by placing it upon a sheet of thin metal somewhat larger than itself, the whole central portion of which within a centimeter of the edge has been removed. The thin metal is folded over the edges of the mica which are to be brought into contact, and they are then held in place by a narrow strip bent transversely upon itself until it has the section of the letter C (Fig. 3). The mica is thus readily bent without cleaving or rumpling.

The distal end of the cylinder is covered with a perforated disk like the top of a pepper box, and to the disk are fastened two wire springs, R R, by which the cylinder is quickly and firmly secured to the flange at the opposite end. The well-made steatite tip, N, should have such an internal diameter that the coal gas under full head will send the flame to the top of the lantern.

The central gas supply tube is bent at right angles into the axis of revolution, and by means of a leather washer is made gas-tight in the socket, O. Commencing just below the gas tip, the oxygen supply tube is made concentric with

the former, until, being bent at a right angle, it leaves it to form with it the shaft of the instrument. The joints at C and E are made gas tight with little friction by the slight inward spring of the iron supports.

The lantern is revolved by a multiplying wheel, or by a powerful clockwork, when a uniform motion is required. Fig. 4 shows the general arrangements of parts.

When the oxygen is diluted with two measures of air it is more easily regulated as a supporter of combustion. The brilliancy of the flame is considerably increased by conducting the coal gas through a sponge saturated with "gasoline."

By regulating the flow of gases and giving the flame a rapid rotation, a continuous brilliant ring is produced, which is broken up into saw-like teeth, characteristic of the pitch, intensity, and quality of the entering sounds. A shrill whistle produces teeth so fine that they are barely visible at a distance of thirty feet. A loud low sound of the human voice affords teeth of the height of the lantern, three or more inches long, with one or two harmonic teeth surmounting the fundamentals. A rough roar yields large, jagged teeth, exceedingly complicated and curious.

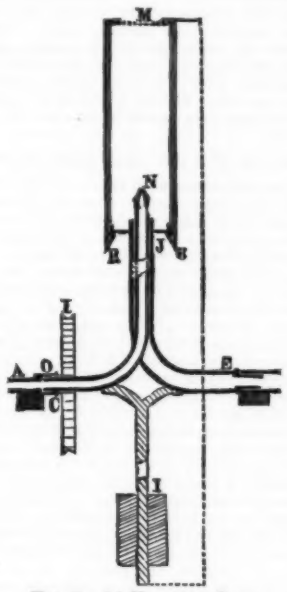



FIG. 2.—⅓ NATURAL SIZE.

On turning down the flame the teeth are reduced to brilliant dots, with smaller dots between them if the harmonics be present. It is curious to observe that no trace of flame can be seen between these dots, which may be three inches or more apart. It is not to be presumed, however, that the flame is extinguished, as it is possible to arrange the flow of gases so that the flame is invisible during a complete rotation, and yet be restored by simply altering the proportion of the inflammable gases.

For investigating the motions of sonorous bodies an attachment is substituted for the manometric capsule, which may be called the manometric pad, which is represented in Fig. 5. This consists simply in a wooden funnel, the mouth of which is covered with thin rubber, and the neck connected with two flexible tubes, one of which brings the supply of coal gas, and the other conveys the sonorous vibrations to the revolving lantern. On placing the manometric pad distended with gas in direct contact with vibrating strings, bells, tuning forks, etc., their movements are readily studied in the flame band. By sliding the pad over

FIG. 3.

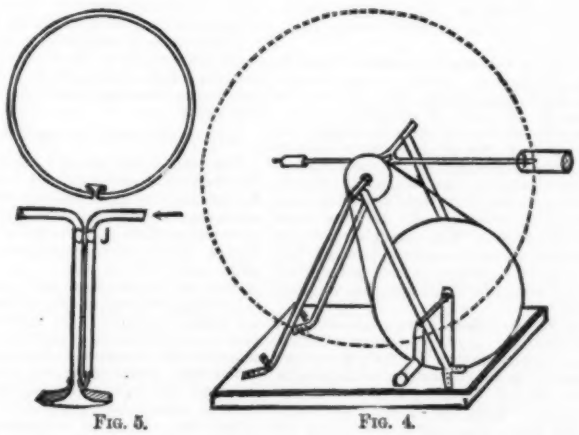


FIG. 5. FIG. 4.

the sonorous body the node and vibration segments are readily located. The interference and extinction of sounds may easily be presented by this apparatus.

The revolving flame was designed primarily for the elucidation of the principles of sound, and this it renders simple by the clearness and brilliancy of its phenomena, as well as the direct view of the vibrating flame which it gives instead of the image usually seen.

For purposes of research the lantern is given a uniform rate, and the length of the flame band made a simple multiple of the wave length. There appears to be no limit to the velocity of rotation, although when the radius is made shorter or the velocity made greater than has been found as yet necessary, it will probably be preferable to introduce the jet at the outer end of the lantern, as only thus can the heated gases of combustion flow as the force of rotation would impel them. A lantern upon the end of a long wand, to which a thin flexible tube leads, is easily constructed by any one, and when waved back and forth gives only less effectually the phenomena of the revolving lantern. Owing to the brilliancy of the flame, there is presumably no difficulty in the way of the direct photography of it.—*Amer. Jour. of Science.*

## THE ROCHESTER ASTRONOMICAL OBSERVATORY.

THE advancement of any great science is always a matter of public interest, and accustomed as the people of America are to wonderful discoveries in the world of invention, they take no less delight in those revelations which concern the material universe, including the most remote heavenly bodies.

The erection of a new building, therefore, which is designed to advance the study of astronomy in all its departments, is a matter of both national interest and universal importance. Such is just what the Warner Observatory at Rochester, N. Y., is designed to do. Being the finest private Observatory in the world, and containing a telescope third in power to any on this continent, it cannot fail to contribute largely to the cause of science in the United States.

But however much may be accomplished in the future, American astronomers have already done grandly in the past. Among the prominent revelations which they have made to the world may be mentioned the following: the separation of Biela's comet into two parts in 1845; the discovery of the eighth satellite of Saturn, in 1848, by Professor Bond; the discovery of the transparent ring of Saturn, in 1850, by Bond. Professor Hall, of the Washington Observatory, discovered the two moons which accompany Mars, which was one of the greatest astronomical events of the present century. In addition to the above, the United States claims the discovery of more than one thousand double and triple stars (among them some of the most wonderful in the entire list of those objects), over fifty asteroids, and fifteen new comets, while Professors Watson and Swift during the eclipse of 1878, discovered three intra-Mercurial planets. This is a record of which Americans can justly be proud.

The new Observatory at Rochester is to be a large and airy building, specially designed for astronomical purposes, and its endowment is due to a fortunate circumstance. The original idea was to construct a tower and building of moderate proportions, but the financial success of Mr. H. H. Warner, who made the original endowment and is the proprietor of the Safe Kidney and Liver Cure and other remedies, induced that gentleman to expend a much larger sum, and make the building what it is as shown below. The new telescope will cost about $15,000, and is to be in charge of

ROCHESTER ASTRONOMICAL OBSERVATORY.

Professor Lewis Swift, who has become so famous by reason of his discoveries of comets and two intra-Mercurial planets. The tube of the new instrument is twenty-two feet in length, while the lens is sixteen inches in diameter. It will be mounted in the revolving turret, so as to most thoroughly sweep the horizon in all possible directions.

The advancement which science has made in the last few years has been very great, but much more may reasonably be expected in the future; and although the locality of Rochester is not well designed for astronomical researches, as there are so many storms in that region, still much may be looked for from the new Warner Observatory in the very near future.

## TEMPERATURE OF THE SOIL IN WINTER.

THE French physicists, MM. Edmond and Henry Becquerel, says the *Gardener's Chronicle*, took advantage of the intense cold prevailing at Paris last December to study the changes in temperature below the surface of the soil under various conditions. It is a widely-spread belief among farmers that, when protected by a layer of snow, crops sown in the autumn are effectually guarded against freezing. This opinion, however, must lose much of its weight in view of these late observations, which may be briefly summarized as follows:

The observations were made by means of Becquerel's electric thermometer, which consists simply of two wires, isolated by a coating of gutta percha, and soldered together at their extremities. Differences in temperature between the two places of junction cause electric currents, varying in intensity with the greatness of the difference. A magnetic needle, brought under the influence of the current, registers on a dial these differences: The wires were inserted in the ground at the Jardin des Plantes at various depths, varying from two to twenty-four inches, and observations were made from November 26 to the close of December. Frost first appeared in the garden November 26. December 3 snow fell in abundance, and the temperature of the air sank —11° C. The layer of snow was ten inches deep. December 10 the temperature had sunk to —21°, and began then gradually to rise. December 15 the snow was seven inches deep. Coming now to the observations made below the surface of the ground under the above circumstances, we find at once a striking difference between the results obtained in soil covered with grass and those obtained below a bare surface of the ground. In soil protected by grass, before as well as after the snowfall, at all depths below that of two inches, the temperature never descended below 0° C. Registering 3·5° at the depth of two inches on November 26, it slowly sank to 0·18° on December 14. The presence of grass would appear, then, to effectually protect the earth beneath it from freezing at the lowest temperatures attained in our climate. Quite different results, however, are yielded in the absence of grass. In this case, at a depth of two inches, the thermometer sank below zero on November 27. Two days later it registered —2·6°. On December 3, just before the

snowfall, it reached its minimum of —3·17°. After being covered with snow it registered —0·8°, and later —1·4°. The snow here appears to act in a certain measure as a screen against changes in temperature, but its conductive properties are still too marked to prevent these changes from being felt sensibly at a certain depth in the earth. In the case of the agriculturist this slow conduction, when united to the still slower conductive properties of a tolerably thick layer of dead shoots of cereal crops sown in autumn, may frequently insure immunity from freezing to the roots below the surface.

## THUNDERSTORMS.*

By PROFESSOR TAIT.

WHEN I was asked to give this lecture I was also asked to give a short list of subjects from which your directors might select what they thought most fit. I named three. Regarded from the scientific point of view, one of them was to be considered as fully understood in principle, and requiring only additional experimental data to make it complete. This was the *Conduction of Heat in Solids*. Another was to a certain extent scientifically understood, but its theory was, and still is, in need of extended mathematical development. This was the popular scientific toy, the *Radiometer*. The third was, and remains, scarcely understood at all. Of course, it was at once selected for to-night. I might have foreseen that it would be. You may well ask, then, why I am here. What can I say about a subject which I assert to be scarcely understood at all? A few years ago no qualified physicist would have ventured an opinion as to the nature of electricity. Magnetism had been (to a certain extent, at least) cleared up by an assumption that it depended on electric currents; and from Oersted and Ampère to Faraday and Thomson, a host of brilliant experimenters and mathematicians had grouped together in mutual interdependence the various branches of electro-dynamics. But still the fundamental question remained unsolved, *What is electricity?* I remember Sir W. Thomson, eighteen years ago, saying to me, "Tell me what electricity is, and I'll tell you everything else." Well, strange as it may appear to you, I may now call upon him to fulfill his promise. And for good reasons, as you shall see. Science and Scotland have lately lost in Clerk-Maxwell one of their greatest sons. He was, however, much better known to science than to Scotland. One grand object which he kept before him through his whole scientific life was to reduce electric and magnetic phenomena to mere stress and motions of the ethereal jelly. And there can be little doubt that he has securely laid the foundation of an electric theory—like the undulatory theory of light admirably simple in its fundamental assumptions, but, like it, requiring for its full development the utmost resources of mathematical analysis. It cannot but seem strange to the majority of you to be told that we know probably as much about the secret mechanism of electricity as we do about that of light, and that it is more than exceedingly probable that a ray of light is propagated by electric and electro-magnetic disturbances. It is one of the most remarkable advances made during this century.

But to know what electricity is does not necessarily guide us in the least degree to a notion of its source in any particular instance. We might know quite well *what* is electricity and yet be, as I told you at starting we *are*, almost entirely uncertain of the exact source of *atmospheric* electricity.

To come to my special subject. I am not going to try to describe a thunderstorm. First, because I am certain that I could not do it without running the risk of overdoing it, and thus becoming sensational instead of scientific; and secondly, because the phenomenon must be quite familiar, except perhaps in some of its more singular details, to every one of you.

Science has to deal with magnitudes which are very much larger or smaller than those which such words as huge, enormous, tiny, or minute are capable of expressing. And though an electric spark, even from our most powerful artificial sources, appears to the non-scientific trifling in comparison with a mile-long flash of lightning, the difference (huge, if you like to call it) is as nothing to others with which scientific men are constantly dealing.

The nearest star is as much farther from us than is the sun, as the sun is farther from us than is London. The sun's distance is ninety-three millions of miles. If that distance be called enormous, and it certainly is so, what adjective have you for the star's distance? Ordinary human language, and especially the more poetic forms of it, were devised to fit human feelings and emotions, and not for scientific purposes. A thoroughly scientific account of a thunderstorm, if it were possible to give one, would certainly be at once ridiculed as pedantic.

### PROMINENT FEATURES OF A THUNDERSTORM.

Let us, therefore, instead of attempting to discuss the phenomenon as a whole, consider separately some of its more prominent features. And first of all, what are these features when we are *in* the thunderstorm?

By far the most striking, at least if the thunderstorm come on during the day, is the extraordinary darkness. Sometimes at mid-day in summer the darkness becomes comparable with that at midnight, very different in kind as well as intensity from that produced by the densest fog. Objects are distinctly visible through it at distances of many miles, whether when self luminous or when instantaneously lit up by lightning. The darkness, then, is simply intense *shadow*, produced by the great thickness and great lateral extension of the cloud masses overhead. Seen from a distance, the mass of cloud belonging to the storm usually presents a most peculiar appearance, quite unlike any other form of cloud. It seems to boil up, as it were, from below, and to extend through miles of vertical height. The estimated height of its lower surface above the ground varies within very wide limits. Saussure has seen it as much as three miles; and in one case noticed by De l'Isle it may have been as much as five miles. On the other hand, at Pondicherry and Manila it is scarcely ever more than half a mile. Haidinger gives the full details of an extraordinary case, in which the thundercloud formed a stratum of only twenty-five feet thick, raised thirty yards above the ground. Yet two people were killed on this occasion. Other notable instances of a similar extreme character are recorded.

### ELECTRICITY IN THE AIR.

Careful experiments show us that the air is scarcely ever free from electricity, even in the clearest weather. And even on specially fine days, when large separate cumuli are floating along, each as it comes near produces a marked effect on the electrometer. Andrews obtained by means of a kite, on a fine clear day, a steady decomposition of water by the electricity collected by a fine wire twisted round the string. Thanks to Sir W. Thomson, we can now observe atmospheric electricity in a most satisfactory manner. I will test, to show you the mode of proceeding, the air inside and outside the hall. [The experiment was shown, and the external air gave *negative* indications.]

On several occasions I have found it almost impossible, even by giving extreme directive force to the instrument by means of magnets, to measure the atmospheric potential with such an electrometer, and had recourse to the old electroscope, with specially long and thick gold leaves. On February 26, 1874, when the sleet and hail, dashing against the cupola of my class-room, made so much noise as to completely interrupt my lecture, I connected that instrument with the water-dropper, and saw the gold leaves discharge themselves against the sides every few seconds, sometimes with positive, sometimes often immediately afterwards, with negative electricity. Such effects would have required for their production a battery of tens of thousands of cells. Yet there was neither lightning nor thunder, and the water was trickling from the can at the rate of only two and a half cubic inches per minute. Probably had there not been such a violent fall of sleet steadily discharging the clouds we should have had a severe thunderstorm.

### ELECTRICITY FROM RAIN DROPS.

Falling rain drops are often so strongly charged with electricity as to give a spark just before they touch the ground. This "luminous rain," as it has been called, is a phenomenon which has been over and over again seen by competent and trustworthy observers. In the *Comptes Rendus* for November last we read of the curious phenomenon of electrification of the observer's umbrella by a light fall of snow, to such an extent that he could draw sparks from it with his finger.

In calm clear weather the atmospheric charge is usually positive. This is very commonly attributed to evaporation of water, and I see no reason to doubt that the phenomena are closely connected. [A few drops of water were sprinkled on a heated crucible, insulated, and connected with the electrometer.]

There can be no doubt that, whatever be the hidden mechanism of this experiment, the steam has carried with it a strong charge of positive electricity, for it has left the rest of the apparatus with a strong negative charge. We will now try that form of the experiment in another way. [High-pressure steam escaping from a little boiler was made to play upon an insulated conductor furnished with spikes, and connected with the electrometer, which then showed a strong positive charge.]

There are many substances which produce on evaporation far greater electric developments than water does, some of positive, others of negative, electricity. By far the most remarkable in this respect to which attention has yet been called is an aqueous solution of sulphate of copper. (*Proc.* R.S.E., 1862.) The smallest drop of this solution thrown on a hot dish gives an intense negative effect—so great, in fact, that it may be occasionally employed to charge a small Leyden jar. But this, like the smaller effect due to water under similar circumstances, is not yet completely explained.

### THE LIGHT OF LIGHTNING.

The next striking features are the flashes of lightning which at intervals light up the landscape with an intensity which must in the majority of cases far exceed that produced by the full moon. To the eye, indeed, the flash does not often appear to furnish more than the equivalent of average moonlight, but it must be remembered that it lasts for a period of time almost inconceivably short, and that the full effect of light on the eye is not produced until after the lapse of a considerable fraction of a second. Prof. Swan has estimated this interval at about one-tenth of a second; and he has proved that the apparent intensity of illumination for shorter intervals is nearly proportional to the duration. (*Trans.* R.S.E., 1849.) I can illustrate this in a very simple manner.

[Two beams of light were thrown upon the screen by reflection from mirrors, each of which was fixed *nearly* at right angles to an axis. When matters were so adjusted that the brightness of the two illuminated spots was the same, one mirror was made to rotate. The corresponding light spot described a circle about the other, and its brightness became less the larger the circle in which it was made to revolve.]

The lightning flash itself on this account, and for the farther reason that its whole apparent surface is exceedingly small, must be in some degree comparable with the sun in intrinsic brilliancy—though, of course, it cannot appear so. The fact that its duration is excessively short is easily verified in many ways, but most simply by observing a body in rapid motion. The spokes of the wheels of the most rapidly moving carriage appear absolutely fixed when illuminated by its light alone. One can read by its light a printed page stuck on a disk revolving at great speed. But the most severe test is that of Sir Charles Wheatstone's revolving mirror. Seen by reflection in such a mirror, however fast it may be rotating, a flash of lightning is not perceptibly broadened, as it certainly would be if its duration were appreciable.

The apparatus which, in our laboratories, enables us to measure the time which light, moving at nearly 200,000 miles per second, takes to pass over a few feet, is *required* to prove to us that lightning is not absolutely instantaneous. Wheatstone has shown that it certainly lasts less than a millionth part of a second. Take this, along with Swan's datum, which I have just given you, and you see that the apparent brightness of the landscape, as lit up by a lightning flash, is *less than one hundred thousandth part* of what it would be were the lightning permanent. We have thus rough materials for instituting a comparison between the intrinsic brightness of lightning and of the sun.

Transient in the extreme as the phenomenon is, we can still, in virtue of the duration of visual impressions, form a tolerably accurate conception of the form of a flash; and in recent times instantaneous processes of photography have given us permanent records of it. These, when compared with photographic records of ordinary electric sparks, bear out to the full the convictions at once forced by appearances on the old electricians, that a flash of lightning is merely a very large electric spark. The peculiar zigzag form, sometimes apparently almost doubling back on itself, the occasional bifurcations, and various other phenomena of a lightning flash, are all shown by the powerful sparks from an electric machine. [These sparks were exhibited directly, and then photographs of some of them were exhibited.]

The spectroscope has recently given us still more convincing evidence of their identity, if any such should be wanted.

The bifurcations of a flash can puzzle no one who is experimentally acquainted with electricity, but the zigzag form is not quite so easily explained. It is certainly destroyed, in the case of short sparks, by heating the air. [Photographs of sparks in hot and in cold air were exhibited. One of each kind was shown in the diagram. The smoother is that which passed through the hot air. The other passed through the cold air nearer the camera, and is, therefore, not quite in focus.]

Now, heating in a tube or flame not only gets rid of motes and other combustible materials, but it also removes all traces of electrification from air. It is possible, then, that the zigzag form of a lightning flash may, in certain cases at least, be due to local electrification, which would have the same sort of effect as heat in rarefying the air and making it a better conductor.

A remark is made very commonly in thunderstorms, which, if correct, is obviously inconsistent with what I have said as to the extremely short duration of a flash. The eye could not possibly follow movements of such extraordinary rapidity. Hence it is clear that when people say they *saw* a flash go upwards to the clouds from the ground, or downwards from the clouds to the ground, they must be mistaken. The origin of the mistake seems to be a *subjective* one, viz., that the central parts of the retina are more sensitive, by practice, than the rest, and, therefore, that the portion of the flash which is seen directly affects the brain sooner than the rest. Hence a spectator looking toward *either* end of a flash very naturally fancies that end to be its starting-point.

### MOTION AND POWER OF ELECTRICITY.

Before I can go farther with this subject it is necessary that I should give some simple facts and illustrations connected with ordinary machine electricity. These will enable you to follow easily the slightly more difficult steps in this part of our subject which remain to be taken.

Since we are dealing mainly with *motion* of electricity, it is necessary to consider to what that motion is due. You all know that the winds—*i. e.*, motions of the air—are due to differences of pressure. If the pressure were everywhere the same at the same level we should have no winds. Similarly the cause of the motion of heat in a body is difference of temperature. When all parts of a body are at the same temperature there is no change of distribution of heat. Now, electricity presents a strikingly analogous case. It moves in consequence of difference of *potential*. Potential, in fact, plays, with regard to electricity, a part precisely analogous to the *rôle* of pressure, or of temperature, in the case of motions of fluids and of conducted heat. Now the power of an electrical machine may be measured by the utmost potential it can give to a conductor. The greater the *capacity* of the conductor the longer time will be required for the machine to charge it; but no electricity passes between two conductors charged to the same potential. Hence the power of a machine is to be measured by using the simplest form of conductor, a sphere, and finding the utmost potential the machine can give it. It is easily shown that the potential of a solitary sphere is directly as the quantity of electricity, and inversely as the radius. Hence electricity is in equilibrium on two spheres connected by a long thin wire when the quantities of electricity on them are proportional—not to their surfaces, nor to their volumes, as you might imagine—to their radii. In other words, the capacity is proportional to the radius. This, however, is only true when there are no other conductors within a finite distance. When a sphere is surrounded by another concentric sphere, which is kept in metallic connection with the ground, its capacity is notably increased, and when the radii of the spheres are nearly equal the capacity of the inner one is directly as its surface, and inversely as the distance between the two spheres. Thus the capacity is increased in the ratio of the radius of one sphere to the difference of the radii of the two, and this ratio may easily be made very large. This is the principle upon which the Leyden jar depends.

It is found that the work required to put in a charge is proportional to the square of the charge. Conversely, the damage which can be done by the discharge, being equal to the work required to produce the charge, is proportional to the square of the charge, and inversely to the capacity of the receiver. Or, what comes to the same thing, it is proportional to the square of the potential and to the capacity of the conductor directly. Thus, a given quantity of electricity gives a greater shock the smaller the capacity of the conductor which contains it. And two conductors, charged to the same potential, give shocks proportional to their capacities. But, in every case, a doubling of the charge, or a doubling of the potential, in any conductor, produces a four-fold shock.

### HOW ELECTRICITY IS DISTRIBUTED ON A CONDUCTOR.

The only other point I need notice is the nature of the distribution of electricity on a conductor. I say *on* a conductor because it is entirely confined to the surface. Its attractions or repulsions in various directions exactly balance one another at every point in the *substance* of the conductor. It is a most remarkable fact that this is always possible, and in every case in one way only. When the conductor is a single sphere the distribution is uniform. When it is elongated the quantity of electricity per square inch of its surface is greater at the ends than in the middle; and this disproportion is greater the greater is the ratio of the length to the transverse diameter. Hence, on a very elongated body, terminating in a point, for instance, the electric density—that is, the quantity per square inch of surface—may be exceedingly great at the point while small everywhere else. Now, in proportion to the square of the electric density is the outward pressure of the electricity tending to escape by forcing a passage through the surrounding air. It appears from experiments on the small scale which we can make with an electrical machine, that the electric density requisite to force a passage through the air increases under given circumstances, at first approximately as the square root of the distance which has to be traversed, but afterwards much more slowly, so that it is probable that the potential required to give a mile-long flash of lightning may not be of an order very much higher than that producible in our laboratories.

### LIGHTNING RODS.—HOW THEY OPERATE.—THEY MUST BE THOROUGHLY CONNECTED WITH THE GROUND.

But from what I have said you will see at once that under similar circumstances an elongated body must have a great advantage over a rounded one in effecting a discharge of electricity. This is easily proved by trial. [The electric machine being in vigorous action, and giving a rapid series of sparks, a pointed rod connected with the ground was

* Abstract of a recent lecture delivered in the City Hall, Glasgow, by Prof. Tait.

brought into the neighborhood, and the sparks ceased at once.] In this simple experiment you see the whole theory and practical importance of a lightning conductor. But, as a warning, and by no means an unnecessary one, I shall vary the conditions a little and try again. [The pointed rod was now insulated, and produced no observable effect.] Thus you see the difference between a proper lightning rod and one which is worse than useless, positively dangerous. There is another simple way in which I can destroy its usefulness, namely, by putting a little glass cap on the most important part of it, its point, and thus rendering impossible all the benefits it was originally calculated to bestow. [The pointed rod was again connected with the ground, but furnished with a little glass cap. It produced no effect till it was brought within four or five inches of one of the conductors of the machine, and then *sparks* passed to it.] You must be strangely well acquainted with the phases of human perversity if you can anticipate what I am now going to tell you, namely, that this massive glass cap, or *repeller*, as it was fondly called, was only a year or two ago taken off from the top of the lightning rod employed to protect an important public building. [The repeller was exhibited. It resembled a very large soda water bottle with a neck much wider than the usual form.] From the experiments you have just seen it must be evident to you that the two main requisites of an effective lightning rod are that it should have a sharp point (or, better, a number of such points, lest one should be injured), and that it should be in excellent communication with the ground. When it possesses these, it does not require to be made of exceptionally great section; for its proper function is *not*, as is too commonly supposed, to parry a dangerous flash of lightning; it ought rather, by silent but continuous draining, to prevent any serious accumulation of electricity in a cloud near it. That it may [illegible]ally do this it must be thoroughly connected with the ground, or (if on a ship or lighthouse) with the sea. In towns this is easily done by connecting it with the water mains, at sea by using the copper sheathing of the ship, or a metal plate of large surface fully immersed. Not long ago a protected tower was struck by lightning. No damage was done in the interior, but some cottages near its base were seriously injured. From a report on the subject of this accident it appears that the lower end of the lightning rod was "jumped" several feet into the solid rock! Thus we see, in the words of Arago: "False science is no less dangerous than complete ignorance, and that it *infallibly* leads to consequences which there is nothing to justify."

That the lightning rod acts as a constant drain upon the charge of neighboring clouds is at once proved when there is, accidentally or purposely, a slight gap in its continuity. This sometimes happens in ships, where the rod consists of separate strips of metal inlaid in each portion of the mast. If they are not accurately fitted together, a perfect torrent of sparks, almost resembling a continuous arc of light, is seen to pass between them whenever a thunderstorm is in the neighborhood.

I cannot pass from this subject without a remark upon the public as well as private duty of having lightning rods in far greater abundance than we anywhere see them in this country. When of proper conducting power, properly pointed, properly connected with the ground and with every large mass of metal in a building, they afford absolute protection against ordinary lightning—every single case of apparent failure I have met with having been immediately traceable to the absence of one or other of these conditions. How great is their beneficial effect you may gather at once from what is recorded of Pietermaritzburg, viz., that till lightning rods became common in that town it was constantly visited by thunderstorms at certain seasons. They still come as frequently as ever, but they cease to give lightning flashes whenever they reach the town, and they begin again to do so as soon as they have passed over it.

A knight of the olden time in full armor was probably as safe from the effects of a thunderstorm as if he had had a lightning rod continually beside him; and one of the Roman emperors devised a perfectly secure retreat in a thunderstorm in the form of a subterraneous vault of iron. He was probably led to this by thinking of a mode of keeping out missiles, having no notion that a thin shell of soft copper would have been quite as effective as massive iron. But those emperors who, as Suetonius tells us, wore laurel crowns or sealskin robes, or descended into underground caves or cellars on the appearance of a thunderstorm, were not protected at all. Even in France, where special attention is paid to the protection of buildings from lightning, dangerous accidents have occurred where all proper precautions seemed to have been taken. But on more careful examination it was usually found that some one essential element was wanting. The most common danger seems to lie in fancying that a lightning rod is necessarily properly connected with the earth if it dips into a mass of water. Far from it. A well constructed reservoir full of water is *not* a good "earth" for a lightning rod. The better the stone work and cement the less are they fitted for this special purpose, and great mischief has been done by forgetting this.

A few years ago the internal fittings of the lighthouse at Skerryvore were considerably damaged by lightning, although an excellent lightning rod extended along the whole height of the tower.

The real difficulty in these situations, exposed to tremendous waves, lies in effecting a permanent communication between the lightning rod and the sea. But when this is done the sea makes far the best of "earths."

When a lightning rod discharges its function imperfectly, either from insufficient conducting power or because of some abnormally rapid production of electricity, a luminous brush or glow is seen near its point. This is what the sailors call St. Elmo's Fire, or Castor and Pollux. In the records of mountain climbing there are many instances of such discharges to the ends of the alpenstocks or other prominent pointed objects. One very remarkable case was observed a few months ago in Switzerland, where at dusk, during a thunderstorm, a whole forest was seen to become luminous just *before* each flash of lightning, and to become dark again at the instant of the discharge.

Perhaps the most striking of such narratives is one in the memoirs of the Physical and Literary Society of Edinburgh, on Thunder and Electricity, by Ebenezer McFait, M.D

### LIGHTNING FLASHES SEVERAL MILES LONG.

The destructive effects of lightning are familiar to all of you. All the more ordinary effects can easily be reproduced by the help of Leyden jars on a small scale. How small you may easily conceive when I tell you that a three-foot spark is considered a long one, even from our most powerful machines, while it is quite certain that lightning flashes often exceed a mile in length, and sometimes extend to four and five miles. One recorded observation, by a trustworthy observer, seems to imply a discharge over a total length of nearly ten miles.

### EFFECTS OF LIGHTNING.

When a tree is struck by a violent discharge it is usually split up laterally into mere fibers. A more moderate discharge may rupture the channels through which the sap flows, and thus the tree may be killed without suffering any apparent external damage. These results are usually assigned to the sudden vaporization of moisture, and the idea is probably accurate, for it is easy to burst a very strong glass tube if we fill it with water and discharge a jar by means of two wires whose extremities are placed in the water at a short distance from one another. The tube bursts even if one end be left open, thus showing that the extreme suddenness of the explosion makes it act in all directions, and not solely in that of least resistance. When we think of the danger of leaving even a few drops of water in a mould into which melted iron is to be poured, we shall find no difficulty in thus accounting for the violent disruptive effects produced by lightning.

Heated air is found to conduct better than cold air, probably on account of the diminution of density only. Hence we can easily see how it is that animals are often killed in great numbers by a single discharge, as they crowd together in a storm, and a column of warm air rises from the group.

*Inside* a thundercloud the danger seems to be much less than outside. There are several instances on record of travelers having passed *through* clouds from which, both before and after their passage, fierce flashes were seen to escape. Many remarkable instances are to be found in Alpine travel, and specially in the reports of the officers engaged in the survey of the Pyrenees. Several times it is recorded that such violent thunderstorms were seen to form round the mountain on which they were encamped, that the neighboring inhabitants were surprised to see them return alive.

Before the use of lightning rods on ships became general great damage was often done to them by lightning. The number of British ships of war thus wholly destroyed or much injured during the long wars toward the end of the last and the beginning of the present century is quite comparable with that of those lost or injured by gales, or even in battle. In some of these cases, however, the damage was only indirectly due to lightning, as the powder magazines were blown up. In the powder magazine of Brescia, in 1769, lightning set fire to over 2,000,000 lb. of gunpowder, producing one of the most disastrous explosions on record.

A powerful discharge of lightning can fuse not only bell wires, but even stout rods of iron. It often permanently magnetizes steel, and in this way has been the cause of the loss of many a good ship; for the magnetism of the compass needles has been sometimes destroyed, sometimes reversed, sometimes so altered that the compass pointed east and west. And by the magnetization of their steel parts the chronometers have had their rates seriously altered. Thus two of the sailor's most important aids to navigation have been simultaneously rendered useless, or, what is worse, misleading; and this, too, at a time when, because of clouds, astronomical observations were generally impossible. All these dangers are now, however, easily and all but completely avoidable.

A very singular effect of lightning sometimes observed is the piercing of a hole in a conducting plate of metal, such as the lead covering of a roof. In such a case it is invariably found that a good conductor well connected with the ground approaches near to the metal sheet at the part perforated.

The name *thunderbolt*, which is still in use, even by good writers, seems to have been introduced in consequence of the singular effects produced when lightning strikes a sandhill or sandy soil. It bores a hole often many feet in length, which is found lined throughout with vitrified sand. The old notion was that an intensely hot, solid mass, whose path was the flash of lightning, had buried itself out of sight, melting the sand as it went down. It is quite possible that this notion may have been strengthened by the occasional observation of the fall of aerolites, which are sometimes found, in the holes they have made, still exceedingly hot. And at least many of the cases in which lightning is said to have been seen in a perfectly clear sky are to be explained in the same way. Every one knows Horace's lines—

> "Diespiter
> Igni corusco nubila dividens
> Plerumque, per purum tonantes
> Egit equos volucremque currum."

But Virgil's remark is not so commonly known. He is speaking of prodigies of various kinds, and goes on:

> "Non alias coelo ceciderunt plura sereno
> Fulgura; nec diri toties arsere cometae."

It is very singular that he should thus have associated comets and meteorites, which quite recent astronomical discovery has shown to have a common origin.

Another remarkable peculiarity, long ago observed, is the characteristic smell produced when lightning strikes a building or a ship. In old times it was supposed to be sulphurous; nowadays we know it to be mainly due to ozone. In fact, all the ready modes of forming ozone which are as yet at the disposal of the chemist depend upon applications of electricity. But besides ozone, which is formed from the oxygen of the air, there are often produced nitric acid, ammonia, and other compounds derived from the constituents of air and of aqueous vapor. All these results can be produced on a small scale in the laboratory.

Hitherto I have been speaking of lightning discharges similar in kind to the ordinary electric spark, what is commonly called *forked* or *zigzag* lightning. Our nomenclature is very defective in this matter, and the same may be said of the chief modern European languages. For as Arago remarks, by far the most common form of lightning flash observed in thunderstorms is what we have to particularize, for want of a better term, as *sheet-lightning*. He asserts that it occurs thousand-fold as often as forked lightning; and that many people have never observed the latter form at all! It is not at all easy to conceive what can be the nature of sheet-lightning, if it be not merely the lighting up of the clouds by a flash of forked lightning not directly visible to the spectator. That this is, at least in many cases, its origin is evident from the fact that its place of maximum brightness often takes the form of the *edge* of a cloud, and that the *same* cloud-edge is occasionally lit up several times in quick succession. You will remember that we are at present dealing with the appearances observed in a thunderstorm, so that I do not refer to that form of sheet-lightning which commonly goes by the name of *summer-lightning*, and which is not, audibly at least, followed by thunder.

### THE NATURE OF THUNDER.

The next remarkable feature of the storm is the thunder, corresponding, of course, on the large scale, to the snap of an electric spark. Here we are on comparatively sure ground, for sound is very much more thoroughly understood than is electricity. We speak habitually and without exaggeration of the *crash* of thunder, the *rolling* of thunder, and of a *peal* of thunder; and various other terms will suggest themselves to you as being aptly employed in different cases. All of these are easily explained by known properties of sound. The origin of the sound is in all cases to be looked for in the instantaneous and violent dilatation of the air along the track of the lightning flash, partly, no doubt, due to the disruptive effects of electricity of which I have already spoken, but mainly due to the excessive rise of temperature which renders the air for a moment so brilliantly incandescent. There is thus an extremely sudden compression of the air all round the track of the spark, and a less sudden, but still rapid, rush of the air into the partial vacuum which it produces. Thus the sound-wave produced must at first be of the nature of a bore or breaker. But as such a state of motion is unstable, after proceeding a moderate distance the sound becomes analogous to other loud but less violent sounds, such as those of the discharge of guns. Were there few clouds, were the air of nearly uniform density, and the flash a short one, this would completely describe the phenomenon, and we should have a thunder *crash* or thunder *clap* according to the greater or less proximity of the seat of discharge. But, as has long been well known, not merely clouds but surfaces of separation of masses of air of different density, such as constantly occur in thunderstorms, *reflect* vibrations in the air; and thus we may have many successive echoes, prolonging the original sound. But there is another cause, often more efficient than these. When the flash is a long one, all its parts being nearly equidistant from the observer, he hears the sound from all these parts simultaneously; but if its parts be at very different distances from him, he hears *successively* the sounds from portions further and further distant from him. If the flash be much zigzagged, long portions of its course may run at one and the same distance from him, and the sounds from these arrive simultaneously at his ear. Thus we have no difficulty in accounting for the *rolling* and *pealing* of thunder. It is, in fact, a mere consequence, sometimes of the reflection of sound, sometimes of the finite velocity with which it is propagated. The usual rough estimate of five seconds to a mile is near enough to the truth for all ordinary calculations of the distance of a flash from the observer.

The extreme distance at which thunder is heard is not great, when we consider the frequent great intensity of the sound. No trustworthy observation gives in general more than about nine or ten miles, though there are cases in which it is possible that it may have been heard fourteen miles off. But the discharge of a single cannon is often heard at fifty miles, and the noise of a siege or naval engagement has certainly been heard at a distance of much more than 100 miles. There are two reasons for this: the first depends upon the extreme suddenness of the production of thunder; the second, and perhaps more effective, on the excessive variations of density in the atmosphere, which are invariably associated with a thunderstorm. In certain cases thunder has been propagated, for moderate distances from its apparent source, with a velocity far exceeding that of ordinary sounds. This used to be attributed to the extreme suddenness of its production; but it is not easy, if we adopt this hypothesis, to see why it should not occur in all cases. Sir W. Thomson has supplied a very different explanation, which requires no unusual velocity of sound, because it asserts the production of the sound *simultaneously* at all parts of the air between the ground and the cloud from which the lightning is discharged.

### GLOBE LIGHTNING.

We now come to an exceedingly strange and somewhat rare phenomenon, to which the name of *fire ball* or *globe-lightning* has been given. As we are as yet unable to produce anything of this kind by means of our electrical machines, some philosophers have tried to cut the Gordian knot of the difficulty by denying that any such thing can exist. But, as Arago says: "*Où en serions nous, si nous nous mettions à nier tout ce qu'on ne sait pas expliquer?*" The amount of trustworthy and independent evidence which we possess as to the occurrence of this phenomenon is such as must convince every reasonable man who chooses to pay due attention to the subject. No doubt there is a great deal of exaggeration, as well as much imperfect and even erroneous observation, in almost all of these records. But the existence of the main feature (the fire-*ball*) seems to be proved beyond all doubt.

The most marked peculiarities of this species of lightning-discharge are its comparatively long duration and its comparatively slow motion. While a spark, or lightning-flash, does not last longer than about a millionth part of a second, if so long, globe-lightning lasts from one to ten seconds, sometimes even longer, so that a sufficiently self-possessed spectator has time carefully to watch its behavior. The general appearance is that of a luminous ball, which must be approximately spherical, because it always appears circular in outline, slowly and steadily descending from a thundercloud to the ground. It bursts with a loud explosion, sometimes before reaching the ground, sometimes as it impinges, and sometimes after actually rebounding. Its size varies from that of a child's head to a sphere of little less than a yard in diameter. On some occasions veritable flashes of lightning were seen to proceed from large fire-balls as they burst. It is difficult to imagine what these balls can be if they be not a species of natural Leyden jar very highly charged. If it be so, no ordinary lightning-rod can possibly prevent danger from it; and we may thus be able to explain the very few cases in which damage has been done by lightning to thoroughly protected buildings. To guard against this form nothing short of a pretty close net-work of stout copper wires would suffice. Meanwhile I give a brief sketch of *two* out of the long series of descriptions of such phenomena which Arago has patiently collected. The first is given on the authority of Babinet, who was deputed by the Academy of Sciences to make inquiries into the case.

Shortly, but not immediately, after a loud peal of thunder, a tailor who was sitting at his dinner saw the paper ornament which covered his fireplace blown down as if by a gentle breeze, and a globe of fire, about the size of a child's head, came gently out and moved slowly about at a slight elevation above the floor. It appeared bright rather than hot, and he felt no sensation of warmth. It approached him like a little kitten which desired to rub itself in play against his legs; but he drew his feet away, and by slow and cautious movements avoided contact with it. It remained several seconds near his feet, while he leaned forward and carefully examined it. At last it rose vertically to about the level of his head, so he threw himself back in his chair and continued to watch it. It then became slightly

elongated, and moved obliquely toward a hole pierced to the chimney about a yard above the mantelpiece. This hole had been made for the chimney of a stove which was used in winter. "But," as the tailor said, "the globe could not *see* the hole, for paper had been pasted over it." The globe went straight for the hole, tore off the paper, and went up the chimney. After the lapse of time which, at the rate at which he had seen it moving, it would have required to get to the top of the chimney, a terrific explosion was heard, and a great deal of damage was done to the chimney and the roofs around it.

The next is even more striking: In June, 1849, in the evening of one of the days when cholera was raging most formidably in Paris, the heat was suffocating, the sky appeared calm, but summer lightning was visible on all sides. Madame Espert saw from her window something like a large red globe, exactly resembling the moon when it is seen through mist. It was descending slowly toward a tree. She at first thought it was a balloon, but its color undeceived her; and while she was trying to make out what it was she saw the lower part of it take fire ("*Je vis le feu prendre au bas de ce globe*"), while it was still some yards above the tree. The flames were like those of paper burning slowly, with sparks and jets of fire. When the opening became twice or thrice the size of one's hand, a sudden and terrific explosion took place. The infernal machine was torn to pieces, and a dozen flashes of zigzag lightning escaped from it in all directions. The *débris* of the globe burned with a brilliant white light and revolved like a Catharine wheel. The whole affair lasted at least for a minute. A hole was bored in the wall of a house, three men were knocked down in the street, and a governess was wounded in a neighboring school, besides a good deal of other damage.

I have never seen one myself, but I have received accounts of more than one of them from competent and thoroughly credible eye-witnesses. In particular on a stormy afternoon in November, 1868, when the sky was densely clouded over, and the air in a highly electrical state, there was heard in Edinburgh one solitary short, but very loud clap of thunder. There can be no doubt whatever that this was due to the explosion of a fire ball, which was seen by many spectators, in different parts of the town, to descend toward the Calton Hill, and to burst while still about a hundred feet or so above the ground. The various accounts tallied in most particulars, and especially in the very close agreement of the positions assigned to the ball by spectators viewing it from different sides, and in the intervals which were observed to elapse between the explosion and the arrival of the sound.

The remaining phenomena of a thunderstorm are chiefly the copious fall of rain and of hail, and the almost invariable lowering of the barometer. These are closely connected with one another, as we shall presently see.

### WATER THE CHIEF AGENT IN THUNDERSTORMS.

Almost all the facts to which I have now adverted point to water-substance, in some of its many forms, as at least one of the chief agents in thunderstorms. And when we think of other tremendous phenomena which are undoubtedly due to water, we shall have the less difficulty in believing it to be capable of producing thunderstorms also.

First of all let us think of some of the more obvious physical consequences of a fall of a mere tenth of an inch of rain. Suppose it to fall from the lowest mile of the atmosphere. An inch of rain is 5 lb. of water per square foot, and gives out on being condensed from vapor approximately 3,000 units of heat on the centigrade scale. The mass of the mile-high column of air a square foot in section is about 360 lb., and its specific heat about a quarter. Thus its temperature throughout would be raised by about 33° C., or 60° F. For one-tenth inch of rain, therefore, we should have a rise of temperature of the lowest mile of the atmosphere amounting to 3·3° C., quite enough to produce a very powerful ascending current. As the air ascends and expands it cools, and more vapor is precipitated, so that the ascending current is farther accelerated. The heat developed over one square foot of the earth's surface under these conditions is equivalent to work at the rate of a horse-power for twelve minutes. Over a square mile this would be ten million horse-power for half an hour. A fall of one-tenth of an inch of rain over the whole of Britain gives heat equivalent to the work of a million millions of horses for half an hour! Numbers like these are altogether beyond the limits of our understanding. They enable us, however, to see the full explanation of the energy of the most violent hurricanes in the simplest physical concomitants of the mere condensation of aqueous vapor.

I have already told you that the source of atmospheric electricity is as yet very uncertain. Yet it is so common and so prominent a phenomenon in many of its manifestations that there can be little doubt that innumerable attempts have been made to account for it. But when we consult the best treatises on meteorology we find it either evaded altogether or passed over with exceedingly scant references to evaporation or to vegetation. Not finding anything satisfactory in books, I have consulted able physicists, and some of the ablest of meteorologists, in all cases but one with the same negative result. I had, in fact, the feeling which every one must experience who attempts to lecture on a somewhat unfamiliar subject, that there *might* be much known about it which I had not been fortunate enough to meet with.

### THEORIES CONCERNING THE SOURCES OF THE ELECTRICITY OF THUNDERSTORMS.

Some years ago I was experimentally led to infer that mere *contact* of the particles of aqueous vapor with those of air, as they fly about and impinge according to the modern kinetic theory of gases, produced a separation of the two electricities, just as when zinc and copper are brought into contact the zinc becomes positively electrified and the copper negatively. Thus the electrification was supposed to be the result of chemical affinity. Let us suppose, then, that a particle of vapor, after impact on a particle of air, becomes electrified positively (I shall presently mention experiments in support of this supposition), and see what farther consequences will ensue when the vapor condenses. We do not know the mechanism of the precipitation of vapor as cloud, and we know only partially that of the agglomeration of cloud-particles into rain-drops; but of this we can be sure that, if the vapor-particles were originally electrified to any finite potential, the cloud-particles would be each at a potential enormously higher, and the rain-drops considerably higher still. For, as I have already told you, the potential of a free charged sphere is proportional directly to the quantity of electricity on it and inversely to its radius; so when eight equal and equally charged spheres unite into one sphere of double the radius, its potential is four times that of each of the separate spheres. The potential in a large sphere, so built up, is in fact directly proportional to its surface as compared with that of any one of the smaller equal spheres of which it is built.

Now, the number of particles of vapor which go to the formation of a single average rain-drop is expressed in billions of billions; so that the potential of the drop would be many thousands of billion times as great as that of a particle of vapor. On the very lowest estimate this would be incomparably greater than any potential we can hope to produce by means of electrical machines.

But this attempt at explanation of atmospheric electricity presents two formidable difficulties at the very outset.

1. How should the smaller cloud particles ever unite if they be charged to such high potentials, which of course must produce intense repulsions between them?

2. Granting that, in spite of this, they do so unite, how are they separated from the mass of negatively electrified air in which they took their origin?

I think it is probable that the second objection is more imaginary than real, since there is no doubt that the diffusion of gases would speedily lead to a great spreading about of the negatively electrified particles of air from among the precipitated cloud-particles into the less highly-electrified air surrounding the cloud. And if the surrounding air were equally electrified with that mixed with the cloud, there would be no electric force preventing gravity from doing its usual work. This objection, in fact, holds only for the *final* separation of the whole moisture from the oppositely electrified air; and gravity may be trusted to accomplish this. That gravity is an efficient agent in this separation is the opinion of Prof. Stokes. It must be observed that as soon as the charge on each of the drops in a cloud rises sufficiently, the electricity will pass by discharge to those which form the bounding layer of the cloud.

The first objection is at least partially met by the remark that in a cloud mass when just formed, if it be at all uniform, the electric attractions and repulsions would approximately balance one another at every point, so that the mutual repulsion of any two water drops would be almost compensated, except when they came very close to one another.

But there is nothing in this explanation inconsistent with the possibility that the particles of water may be caused to fly about repeatedly from cloud to cloud, or from cloud to an electrified mass of air; and in many of these regions the air, already in great part deprived of its moisture, may have become much cooled by expansion as it ascends, so that the usual explanation of the production of hail is not, at least to any great extent, interfered with.

I may here refer to some phenomena which seem to offer, if closely investigated, the opportunity for the large scale investigations which, as I shall presently show, will probably be required to settle the source or sources of atmospheric electricity.

First, the important fact, well known nearly 2,000 years ago, that the column of smoke and vapor discharged by an active volcano gives out flashes of veritable lightning. In more modern times this has been repeatedly observed in the eruptions of Vesuvius and other volcanoes.

Sabine, while at anchor near Skye, remarked that the cloud cap on one of the higher hills was permanently luminous at night, and occasionally gave out flashes resembling those of the aurora. I have not been able to obtain further information as to this very important fact; but I have recently received a description of a very similar one from another easily accessible locality.

My correspondent writes from Galway, to the following effect, on the second of September:

"At the commencement of the present unprecedentedly long and severe storm the wind blew from southwest and was very warm. After blowing for about two days it became, *without change of direction*, exceedingly bitter and cold; and the rain was, from time to time, mixed with sleet and hail, and lightning was occasional. This special weather is common for weeks together in March or early April. The air is (like what an east wind brings in Edinburgh) cold, raw, dry, and in every way uncomfortable, especially to people accustomed to the moist Atlantic winds. During these weeks a series of small clouds, whose shadows would only cover a field of a few acres, seem to start at regular intervals from the peaks of hills in Connemara and Mayo. They are all more or less charged with electricity. From high ground, behind the city, I have at one time seen such a cloud break into lightning over the spire of the Jesuits' church. At another, I have seen such a cloud pour down in a thin line of fire, and fall into the bay in the shape of a small incandescent ball. On one occasion I was walking with a friend, when I remarked, 'Let us turn and make a run for it. We have walked unwittingly right underneath a little thundercloud.' I had scarcely spoken when a something *flashed on the stony ground at our very feet*, a tremendous crash pealed over our heads, and the smell of sulphur was unmistakable. I fancy that I have been struck with these phenomena more than others, from the circumstance that they have always interfered with my daily habits. My walks often extended to considerable distances and to very lonely districts. Now these small local spurts of thunderstorms would hardly excite attention in the middle of a town, all the less as the intervening weather is bright, though raw—these spurts coming on every three or four quarters of an hour. Neither would they excite much attention in the country, as, while such a little storm was going on in one's immediate neighborhood, you would see at no great distance every sign of fine weather. In fact, they always seem to me like the small change of a big storm."

My correspondent, though a good observer and eloquent in description, is not a scientific man. But it is quite clear from what he says that a residence of a few weeks in Galway, at the proper season, would enable a trained physicist to obtain, with little trouble, the means of solving this extremely interesting question. He would require to be furnished with an electrometer, a hygrometer, and a few other simple pieces of apparatus, as well as with a light suit of plate armor, not of steel, but of the best conducting copper, to insure his personal safety. Thus armed he might fearlessly invade the very nest or hatching place of the phenomenon, on the top of one of the Connemara hills. It is to be hoped that some of the rising generation of physicists may speedily make the attempt, in the *spirit* of the ancient chivalry, but with the offensive and defensive weapons of *modern* science.

Another possible source of the electricity of thunderstorms has been pointed out by Sir W. Thomson. It is based on the experimental fact that the lower air is usually charged with negative electricity. If ascending currents carry up this lower air the electricity, formerly spread in a thin stratum over a large surface, may, by convection, be brought into a very much less diffused state, and thus be raised to a potential sufficient to enable it to give a spark.

However the electrification of the precipitated vapor may ultimately be accounted for, there can be no doubt of the fact that at least as soon as *cloud* is formed the particles are electrified; and what I have said as to the immense rise of potential as the drops gradually increase in size remains unaffected. I have tried various forms of experiment, with the view of discovering the electric state of vapor mixed with air. For instance, I have tested the vapor which is suddenly condensed when a receiver is partially exhausted; the electrification of cooled bodies exposed to moist air from a gasholder; and the deposition of hoar frost from a current of moist air upon two polished metal plates placed parallel to one another, artificially cooled, and connected with the outer and inner coatings of a charged jar. All have given results, but as yet too minute and uncertain to settle such a question. These experiments are still in progress. It appears probable, so far, that the problem will not be finally solved until experiments are made on a scale much larger than is usual in laboratories.

A great thunderstorm in summer is, in the majority of cases, preceded by very calm sultry weather. The atmosphere is in a state of unstable equilibrium, the lower strata are at an abnormally high temperature, and highly charged with aqueous vapor. It is not easy, in a popular lecture like this, to give a full account of what constitutes a state of stable equilibrium, or of unstable, especially when the effects of precipitation of vapor are to be largely taken into account. It is sufficient for my present purpose to say that in all cases of thoroughly stable equilibrium, a slight displacement *tends to right itself*; while, in general, in unstable equilibrium, a slight displacement tends to increase. Now, if two cubic feet of air at different levels could be suddenly made to change places, without at first any other alteration, and if, on being left to themselves, each would, under the change of pressure which it would suddenly experience, and the consequent heating or cooling, with its associated evaporation or precipitation of moisture, tend to regain its former level, the equilibrium would be stable. This is not the case when the lower strata are very hot and fully charged with vapor. Any portion accidentally raised to a higher level tends to rise higher, thus allowing others to descend. These, in consequence of their descent, tend still farther to descend, and thus to force new portions up. Thus, when the trigger is once pulled, as it were, we soon have powerful ascending currents of hot moist air, precipitating their moisture as cloud as they ascend, cooling by expansion, but warmed by the latent heat of the vapor condensed. This phenomenon of ascending currents is strongly marked in almost every great thunderstorm, and is precisely analogous to that observed in the center of a West Indian tornado and of a Chinese typhoon.

When any portion of the atmosphere is ascending it must be because a denser portion is descending, and whenever such motions occur *with acceleration* the pressure must necessarily be diminished, since the lower strata are not then supporting the whole weight of the superincumbent strata. If their whole weight were supported they would not descend. Thus even a smart shower of rain must directly tend to lower the barometer. [A long glass tube, filled with water, was suspended in a vertical position by a light spiral spring, reaching to the roof of the hall. A number of bullets hung at the top of the water column, attached to the tube by a thread. When the thread was burned, by applying a lamp, the bullets descended in the water, and *during their descent* the spring contracted so as to raise the whole tube several inches.]

In what I have said to-night I have confined myself mainly to *great* thunderstorms, and to what is seen and heard by those who are within their sphere of operation. I have said nothing of what is commonly called *summer lightning*, which is probably, at least in a great many cases, merely the faint effect of a distant thunderstorm, but which has also been observed when the sky appeared tolerably clear, and when it was certain that no thunderstorm of the ordinary kind had occurred within a hundred miles. In such cases it is probable that we see the lightning of a storm which is taking place in the upper strata of the atmosphere, at such a height that the thunder is inaudible, partly on account of the distance, partly on account of the fact that it takes its origin in air of small density.

Nor have I spoken of the aurora, which is obviously connected with atmospheric electricity, but in what precise way remains to be discovered. Various theories have been suggested, but decisive data are wanting. Dr. Balfour Stewart inclines to the belief that great auroras, visible over nearly a whole terrestrial hemisphere, are due to inductive effects of changes in the earth's magnetism. This is not necessarily inconsistent with the opinion that, as ordinary auroras generally occur at times when a considerable change of temperature takes place, they are phenomena due to the condensation of aqueous vapor in far less quantity, but through far greater spaces, than the quantities and spaces involved in ordinary thunderstorms.

In taking leave of you and of my subject I have two remarks to make. First, to call your attention to the fact that the most obscure branches of physics often present matter of interesting reflection for all, and, in consequence, ought not to be left wholly in the hands of professedly scientific men. Secondly, that if the precautions which science points out as, at least in general, sufficient, were recognized by the public as *necessary*, the element of danger, which in old days encouraged the most debasing of superstitions, would be all but removed from a thunderstorm. Thus the most timid would be able to join their more robust fellow-creatures in watching fearlessly, but still, of course, with wonder and admiration, one of the most exquisite of the magnificent spectacles which nature from time to time so lavishly provides.

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## FORMATION OF HIPPURIC AND BENZOIC ACIDS IN THE ANIMAL ORGANISM DURING FEVER.

By T. WEYL and B. v. ANREP.

THE normal urine of rabbits fed with milk and oats contains hippuric acid, and mostly also free benzoic acid; during fever the quantity of free benzoic acid increases, whilst that of the hippuric acid diminishes; this does not depend solely on the deficiency of glycocol. The absolute quantity of benzoic acid present during fever is not greater than in the normal condition, but the form in which it occurs is different.

The normal urine of a dog fed with fatty and albuminous food always contains hippuric acid, and mostly also small quantities of free benzoic acid. During fever the hippuric acid diminishes. In a healthy dog the greater part of the benzoic acid is converted into hippuric acid, whereas during fever the benzoic acid occurs in the free state to a greater extent than under normal conditions.

## MARIE JOSEPH JACQUARD.

By HUGH MCCALL.

ACCORDING to sacred history the art of producing pictures on textile fabrics, either by the shuttle of the weaver or the needle of the embroiderer, was cultivated in Palestine at an early period of the world's annals.

Antiquarians have stated that the science of producing material for clothing purposes was originally introduced into Europe by the wandering tribes of Phœnicians. Much difference of opinion exists on the subject, but whether or not such was the fact, there cannot be any doubt that fancy work formed a source of pastime for the higher classes, and of emoluments for the working people, in times far in the distance.

It was not, however, until about the last half of the past century that the genius of different lands opened, as it were, a new world of manufactures, and strange to say, all or nearly all the wonderful inventions of that age were brought into play by men whose pursuits in life had nothing whatever to do with their discoveries. James Watt, to whom we are indebted for the practical adaptation of steam as a motive power, was originally a maker of nautical instruments. Richard Arkwright, through whose ingenuity cotton spinning by mechanical power became a reality, commenced his industrial life as a hairdresser, and, throwing curling tongs and wig blocks into the corner, he studied mechanical philosophy with such effect as to bring out a machine that totally revolutionized cotton spinning.

Many other evidences of genius which displayed itself in departments of labor that had no connection whatever with those in which new inventions were brought out may also be noted. The neglected James Hargreaves, a carpenter, was decidedly possessed of much higher talent than the Bolton hairdresser could boast of. He produced the spinning jenny, the greatest and most effective of all the inventions of his age. In the manufacture of cloth, much improvement had been introduced, chiefly through the superior description of looms constructed for weaving. Hand work alone was the medium of production until the Rev. Dr. Cartwright, a Lancastershire rector, discovered the principle of the power loom. This was in 1784, and when the first crude machine came out there seemed to be no end of the ridicule poured on the head of the reverend originator. Manchester men laughed at the idea of a parson being able to do anything outside reading the morning service of the church and preaching a dull sermon, but in a very few years, and after the loom had received many finishing touches, the manufacturers who had made themselves merry at Dr. Cartwright's expense reaped the greatest advantages by availing themselves of the new machine.

The production of linen damask occupied much attention throughout the north of Ireland from the period of the Huguenot settlement, commencing with 1690. Wonderful tales were told of the perfection to which the weavers of Damascus had arrived in the art of producing pictures and landscapes on the uncolored surface of flaxen fabrics, and a desire to emulate the workmen of the Holy Land stirred into action the genius and skill of many weavers. James Quinn of Carlow, Richard Holden of Waringstown, Patrick Smith of Belfast, and William Coulson of Lisburn, had each in his own way contributed to the progress of the manufacture as well in the superior make of fancy looms as by the improvements in the gearing. But even the best of construction of these machines was found to have much of the cumbrous about them, and until the Gallic genius Marie Joseph Jacquard had thrown the light of his inventive faculties across the manufacturing world the fancy trade in woven fabrics was still trammeled by many obstructions. That very remarkable Frenchman was the son of a silk weaver who resided in an humble quarter of the city of Lyons, where the juvenile was born in October, 1752.

The population of that great capital of what may be called classic manufactures was then about 100,000, of which number fully one-tenth consisted of weavers and embroiderers. Jacquard's boyish days, like those of many other sons of genius, were alternately darkened by clouds and brightened by sunshine. France was then suffering under the tyrannical dynasty of the Bourbons, and as weavers' workships have ever been debating societies in which the administrative course of king and cabinets was sharply criticised, young Jacquard, who had been apprenticed to his father at the age of fourteen, learned to talk politics long before he had become even a tyro in the art of weaving. He had only got out of his teens when he married a straw bonnet maker. The young wife kept a small shop in the city, and for many years the pair lived in all the enjoyment of contented industry. Jacquard in the meantime had gathered sufficient funds to purchase half a dozen looms, and, while his wife attended to the bonnet making, he, with five assistants, worked diligently at silk weaving. When the revolution broke out Jacquard joined the malcontents and fought gallantly in the cause which he considered a righteous one, but on his return home he found that desolation had been at work there during his absence; the bonnet business had declined so much that his wife was obliged to dispose of the silk looms, and her little shop was also given up. Accommodating himself to these adverse circumstances, and his partner being blessed with a naturally cheerful disposition, he bore the change of fortune with great magnanimity. Jacquard rented a small cottage on the borders of the Rhone, and turned his sole attention to straw-plait manufacture, importing into it much of the fanciful and raising the trade far above what it had been when he kept his shop in the city. While working at his new phase of industry he had been indulging in dreamy ideas respecting mechanical power, and in 1799 he brought out a straw-plait machine which proved to be quite a success. He had previously made some improvements in the construction of silk looms, but this was the first offspring of his genius, and the fact that on that machine he could produce five times the quantity of work which he had ever done by hand caused him to be looked upon as a celebrity and raised him up many friends. One day a neighbor called at the cottage, and in course of conversation told him that he had seen in Galignani's newspaper an advertisement from a gentleman in Cornwall, England, offering some handsome reward for the invention of a machine that would weave fishing nets. The only mode of producing those nets was then by hand work, and the demand for them had increased so much that the supply could not be had. Many attempts had been made to supersede the existing system, but the difficulty of inventing a contrivance by which knots could be tied on straight cords remained unsurmounted. Having obtained the Cornish gentleman's address Jacquard wrote him to say that he thought the work might be accomplished. A satisfactory reply came in due course, and he set about the proposed invention with the determination of succeeding. After several weeks' study and labor, during which he threw aside many of the germs of crude conceptions, he at length produced the machine which fully performed the work. It was sent over to Cornwall, and having been found well adapted to the purpose required, the advertiser sent the Rhone-side cottager a still higher reward than he had promised him. The invention caused considerable discussion on both sides the Straits, and was hailed with delight in the homes of the Cornish fishermen.

Some time before that to which we refer Bonaparte had been elevated to the position of First Consul of France. Wonderful stories were told of the great success of Jacquard's achievements, and the morbid desire of the famous Corsican to make his country independent of all other nations was raised to the uttermost respecting the net-producing machines. With his usual impulse Bonaparte ordered two of his guards off to Lyons armed with power to seek out Jacquard and bring him to Paris. The soldiers duly arrived in the city of silk looms, and when they appeared before the cottage door of the straw-plait maker the greatest consternation was felt in that quiet household. After some explanation, however, the fears of the family were pretty well allayed, the guards stating that the First Consul's command was of a friendly character and would likely prove highly advantageous to Monsieur Jacquard. On arriving in Paris the straw-plait manufacturer was at once ushered into the presence of Bonaparte. "You have invented a net machine," said the First Consul. Jacquard bowed. "I can scarcely credit all I have heard on the subject," continued the great man, "but in order to test your skill as a mechanician, arrangements have been made for your being placed in apartments where every personal comfort will be at your command. Servants have been told off to attend you, and there is also provided every material and the tools required for making the machine. There, however, you must remain from this day and until you have finished a contrivance for net weaving." Bewildered by the novelty of the situation Jacquard was only able to stammer out a few words indicating his readiness to comply with the command, when Bonaparte waived his hand and the guards hurried off their captive to the place of his confinement. Never before had Jacquard been the object of so much attention as was paid him on that remarkable occasion. In a handsome suite of rooms, situated in a rear wing of the palace, he was attended by liveried lackeys, and at his hand were placed ample supplies of materials and artisans' tools, but some hours had passed before he could realize the novelty of his position. Nearly all his earlier studies had been carried out either under his father's humble roof or at the riverside cottage; but there he was, the occupant of splendid apartments richly decorated, and in which at one time royalty had reveled in the very fullness of monarchial greatness, but yet a prisoner. Next day he commenced work, and for the first week he did little else than take down in the evening what he had set up some hours before. He was determined to improve on the Cornwall machine, and after much labor and many sleepless nights he succeeded in making something very superior to the first one. Bonaparte had been most anxious to improve the national fisheries, and Jacquard's invention was hailed by him with enthusiasm and as something which would give the people on the coast of France increased facilities for gathering in the harvest of the sea. The fortunate inventor was immediately raised to the courted position of a special favorite of the First Consul, and some time afterward he was appointed Conservatoire des Art et des Metiers, an office of much honor but only of small emolument.

Jacquard's great invention, that by which his name has been handed down to posterity and which will live in all time to come, was still in embryo. He had been brought up as it were in a weaving shop, his father's loom having been among the early objects of his infant gaze, and from that time he always looked with sympathy on the lads that worked as drawboys at the damask loom. He himself had spent several years in that most picturesque of all industrial pursuits, weaving damask silk, and while studying the intricate gearing of these looms had indulged in many visions of improvement, something that would give the skilled operator the means of producing the most intricate patterns with a facility then unknown. Having made a tour through the workshops of Lyons he found by the side of each damask loom the drawboy at his laborious employment, seeming to be a part of the machine itself, and without whose aid the weaver could not get through his work. To relieve that drawboy from his somber occupation became a great object of Jacquard's life, and for that purpose he worked with brain and hands for some months. After much disappointment and great labor he brought out, in December, 1801, that wonderful principle of self-action which has created a new era in fancy weaving and has made the damask weaver quite independent of a drawboy and leaving the latter to adopt some other and better paid source of labor. We may here state that long before Jacquard was born there had been attempts made to bring about the improvements he invented for the damask loom.

In 1731 Richard Holden, of Waringstown, Ireland, produced a machine to be worked without the aid of a drawboy. It was exhibited before the Scottish Linen Board, and Holden received a handsome reward, but the work did not succeed. More than sixty years afterwards a carpet weaver of Kilmarnock, Scotland, familiarly known as Tom Morton, invented a remarkable machine. His system of working fancy fabrics without a drawboy consisted of a revolving drum fixed at the side of the loom, on the barrel of which drum sets of pins had been fixed in such positions that as the drum was turned round by the leather belt the pins raised or lowered the heddles so as to produce the required pattern on the cloth. Jacquard's machine, which had been introduced into Kilmarnock some years afterwards, proved so much superior in practical utility to that of Thomas Morton that the latter readily acknowledged the fact, and throwing aside his own cherished machine he magnanimously adopted that of the famous Frenchman. In many points, but especially in its simplicity of construction, Jacquard's loom differed very materially from all others that had ever been previously brought forward, and in the eyes of the more intelligent manufacturers of Lyons it was considered the art triumph of the day; but numbers of the good old school of capitalists, men whose prejudices led them to despise whatever was new or progressive in the textile arts, refused all recognition of the principle, which, they said, must be injurious to the trade, from the fact that it would throw thousands of lads out of work. True it was that those same lads never earned in their laborious duties as drawboys more than three to four francs for their week's work of eighty hours. Still narrow-minded men thought it would be a great hardship to substitute a mechanical contrivance which would deprive so many young people of employment. Apart, however, from these drawbacks the projector of the new loom had much to exult over; orders poured in on him for machines, and those which he set up for his manufacturing friends performed the work so well that their fame was resounded far beyond the boundaries of Lyons. It was acknowledged that under the system of employing drawboys mistakes were sometimes made which caused weavers immense trouble to rectify, but Jacquard's automaton performed the work with mathematical accuracy; it never got sick or turned out for increased wages, and neither required food nor clothing. Perhaps the most valuable feature of the machine was its simplicity of construction, the leading principle of which consisted of a long roll of card paper perforated on specific rules and according to the design of the pattern about to be produced. This roll of paper was placed on a beam connected with the loom, and as the weaver alternately pressed the treadles with his foot, the revolving wheel acted on the pulley attached to the heddles, and thus performed the part of an automaton drawboy, and the shuttle was passed through the warp, creating in the fabric the exact pattern indicated in the "design." When the weavers of Lyons were made aware of the changes which the improved loom were said to produce their wrath knew no bounds. As it had been in Lancashire, after James Hargreaves brought out his spinning jenny, the prejudices of the operatives were stirred up to semi-madness. The rights of labor, they cried out, were about to be invaded, the wages of workmen would be reduced, and the damask trade ruined. Such was the cry raised, and to this they added the calamity of throwing some thousands of lads out of employment. Meetings of the disaffected were held in the outskirts of the city, and after much airing of their grievances the weavers resolved on having a public procession in order to rouse popular sympathy. On a certain day, and in accordance with that arrangement, several hundreds of the silk weavers marched through the streets of Lyons with banners and headed by a band of music. As the procession passed along the indignant shout, "*A bas Jacquard*," was heard in every variety of intonation, while the riotous aspect of the mob alarmed all classes of peaceable inhabitants. At length the storm which was too loud to last long, partially lulled itself to rest, and after a few weeks of self-inflicted idleness the greater proportion of the operatives had cooled down and returned to their workshops. During the succeeding four years Jacquard made several improvements on the machine of 1801, but even when the latest touch had been given to it envious people ridiculed the idea that he could be the inventor, and charitably suggested that he must have copied the model and then gave it to the world as his own. On one occasion a mob entered his dwelling, and having brought out the looms he was engaged in finishing, they broke them in pieces before his door and threatened to set the house on fire.

While these persecutions were being carried on some far-seeing manufacturers who had adopted the new mode of making silk damasks were reaping large profits. Jacquard, with the usual disinterestedness of his character, had refused to take out a patent for the protection of his rights, and thus the trade could avail themselves of its advantages without paying a single dime to its author. One of the most simple-minded and generous of mortals, he felt that his richest reward lay in the consciousness that in his own day and generation he had accomplished something that would in all time materially benefit his fellow-men. He had raised the position of operatives, given increased energy to capitalists, and added a new trophy to high art in the textile world.

Before the end of the year 1804 the fame of Lyons manufacturers arose to a height far exceeding anything ever before attained. Orders for the superior classes of goods poured in from the principal cities of Europe, and although at that time the English government had laid extra duties on the import of every production of France, the rage for the unique fabrics reigned paramount in London. George the Third, who hated the land of Gaul as heartily as he despised the Corsican that ruled over her destinies, was wroth at the invasion of French silks, but the ladies of that day cared little for the frowns of royalty when the republicanisms of fashion sought their allegiance.

In the meantime French capitalists and workmen enjoyed remarkable prosperity, numbers of the deposed drawboys were raised to the rank of weavers, and the wages of skilled hands at the loom advanced so much that gratitude toward Jacquard prevailed on all sides, and the very men who had threatened to throw the inventor of the new weaving machine into the deepest waters of the Rhone were found joining in the songs of triumph that resounded throughout the workshops of Lyons in honor of their distinguished fellow-citizen. And in the hey-day of Napoleon's glory, when as Emperor of France and King of Italy his name brought terror into some of the loftiest cabinets of Europe, he did not forget the inventor of the net loom. Jacquard was then managing a small manufacturing concern on a miserable salary, when his patron conferred on him a pension for life, equal to about $650 per annum. The income was small, but it exceeded all his expenses so much as to leave a great portion of it for benevolent purposes. On that pension he retired to a small farm situated in the vicinity of Lyons, and there he passed the remainder of his days in all the enjoyment of quiet and unobtrusive philanthropy. His wife and son died soon after his having given up the active duties of life, and, attended by a faithful domestic, he passed the last eight-and-twenty years of his existence in the peaceful calm of Christian benevolence.

Returning good for evil, he soothed by his presence and his purse the last hours of several of the very weavers who had threatened his life in 1802, and thus in acts of private charity sent many a ray of light into the somber abodes of age and poverty. It is very remarkable that during the later days of Jacquard's life, the workpeople of Lyons delighted in doing him honor, while the manufacturers, most of whom had realized fortunes by his improved loom, seemed to have forgotten even the existence of the man whose genius had accomplished so much for the trade; and all the time of his illness the only people connected with the silk manufacture who evinced any sympathy for the sufferer were the weavers.

One prominent characteristic of Jacquard was the feeling of gratitude he entertained for the memory of his imperial patron, Napoleon Bonaparte. Every scrap of the Emperor's history was treasured up in his recollection, and he spoke of the nobler traits in his benefactor's life with all the enthusiasm of hero worship.

Of Sir Hudson Lowe, the petty tyrant, he entertained feelings of horror. "The English government," said Jacquard, "should have maintained their national character for generosity toward a fallen foe, and not have permitted a small jailer like Lowe to persecute the hero of Marengo." Throughout the spring and summer of 1834, Marie Joseph Jacquard rarely left his bedroom, and at the close of an August evening in that year, he requested the attendant to have the little couch on which he lay brought over to a window which looked out over the flower garden in which so many joyous days had been spent. He gazed attentively on those

natural pictures of the beautiful, and, turning on his side, passed peacefully away to the world that lies beyond time. He had then arrived at the good old age of eighty two One of the handsomest monuments that grace the city of Lyons was some time ago erected to his memory.

## DENIS PAPIN.

THE town of Blois has recently honored the memory of one of its worthy sons—Denis Papin—by the erection of a magnificent bronze statue, the work of M. Millet. This work of art, which was exhibited at the late Paris Exhibition, was inaugurated on the 29th of August. The statue is placed at one side of the stairway leading from the quays on the Loire up to the top of the hill on which is built Blois in the form of an amphitheater. The ceremonies took place at two o'clock in the afternoon. In front of the monument

BRONZE STATUE OF DENIS PAPIN, RECENTLY ERECTED AT BLOIS, FRANCE.

were seated many distinguished persons. Orations were delivered by Messrs. Kohn and Wilson, and a history of the life and labors of Papin was read by M. De Lesseps. In the evening a grand banquet took place, at which covers were laid for three hundred guests. Denis Papin, to whom this debt of gratitude has been paid, was a physician and philosopher and one of the most talented of the early experimenters on steam and air; a man of whom any country might have been proud. And, although Catholic France, in her bigotry, cast him out in disgrace as a Protestant, she *now* claims honor to herself for having given him birth, and mourns that the records of his labors are only to be found in foreign archives. Papin was born at Blois in 1647, and died in Marburg, Germany, about 1712. He practiced medicine for some time in Paris, but eventually turned his attention to mechanics. Driven, through persecution, from France, after the revocation of the edict of Nantes, he took refuge in England. Through the influence of the celebrated Boyle he was elected a fellow of the British Royal Society in 1680. He was an active and useful member, and contributed several interesting papers to the Society's Transactions. In 1681 he invented a method of softening bones, with a view to extract nourishing food from them, viz., by submitting them to the action of steam at high temperatures, in close vessels named *digesters*. The principle of this apparatus is still in use, under the name of "Papin's digester." Notwithstanding the practical knowledge of the properties of steam acquired by the employment of digesters, Papin does not appear to have had any idea of using it as a mechanical agent till years after. His first paper on the subject of raising water is dated July, 1685 (Phil. Trans., vol xv., p. 1093), entitled "A New Way of Raising Water Enigmatically Proposed." The device explained in this paper was a small fountain, in which a liquid was raised by a piston bellows, "put in some secret place where a body may play the same." The idea was to furnish a means of transmitting power to a considerable distance by means of *air*. The project was ingenious, but of no practical value, and it failed even in experiment. Various other plans for raising water and transmitting power by air were proposed and tried by him, and although they were unsuccessful, they are interesting for the ingenuity displayed, and also because their failure led him to the employment of other agents. Having been invited by the Landgrave of Hesse to accept the profesorship of mathematics in the University of Marburg, Germany, he left England in 1687, but shortly before his departure he exhibited to the Royal Society some experiments on the application of gunpowder to produce a vacuum. He published an account of these experiments the following year in the *Acta Eruditorum*, a scientific journal at Leipsig. In 1690, unable to obtain a sufficient vacuum with gunpowder, Papin turned his attention to steam. In one of his first essays he raised the piston by the expansive force of the latter, and then allowing it time to cool and return to its former bulk as a liquid, the pressure of the air forced the piston back. His cylinder was two and a half inches diameter, and closed at the bottom. A small quantity of water was introduced through a hole in the piston, which was pushed down to exclude the air below it, and the hole then stopped by a plug. A brazier of burning coals was now applied to the bottom of the cylinder, and the piston consequently raised by the accumulating vapor. When the piston reached nearly to the top of the cylinder it was retained there by a latch slipped into a notch in the piston rod; the fire was now removed, and the atmosphere pressed the piston down and raised a load of sixty pounds, which was attached by a rod and pulley to the piston rod, being an effective force of twelve and a half pounds upon every square inch on the upper surface of the piston. A device of this kind, Papin thought, was applicable to draw water from mines and to propel boats against wind and tide. It does not appear that he made any essential improvement on the apparatus during the four following years. In 1707, according to documents discovered in 1852 by Prof. Kuhlmann in the public library at Hanover, Papin had a vessel built in conformity with his invention, and tried it on the Fulda. It is astonishing that the idea of a fixed and separate boiler never occurred to him. His plan was never tried except as an experiment, and he subsequently abandoned the use of cylinders and pistons, and applied steam to raise water on the plan of Worcester's sixty-eighth proposition. This was unfortunate for his fame; for in his experiments with the piston and cylinder he was in possession of every principle of the low-pressure steam engine, and had he followed up the device he would have borne off the palm from all his cotemporaries. Even the high-pressure engine, and all the glory of its development, was then within his reach; but he was no practical mechanic, and his thoughts became diverted into other

channels. One of the most pleasing and honorable circumstances connected with the history of his labors is the candid admission of several English writers of his great merits, and their generously expressing regret that his attention should have been diverted when he was so near realizing the most splendid reward. His name, however, is inseparably connected with the steam engine, and as long as the safety valve (which he rendered of universal application) shall be used the world will be his debtor. Papin's last published work was an essay entitled a "New System of Raising Water by the Action of Fire" (Frankfort, 1707). One of the machines made from plans described in this work raised water to an elevation of seventy feet, whence it descended and formed a *jet d'eau* in the court of the Hessian Academy of Arts.

Such is an outline of the labors of a man whom his fellow-countrymen have at a late day done so wisely to honor. But what a commentary it is on religious bigotry and persecution, that the only claims which Roman Catholic France has or can set up for a share in the invention of the steam engine are based on the ingenuity of a Jew and a Protestant—on Solomon Decaus and Denis Papin!

## ORNAMENTATION OF ANCIENT AMERICAN POTTERY.

AT a meeting of the Boston Society of Natural History, Mr. F. W. Putnam offered a communication on the principles involved in the ornamentation of the pottery of some of the ancient nations of America, with particular reference to that from the Cumberland Valley in Tennessee, and from Nicaragua, illustrating his subject by a fine series of vessels of various shapes, selected from the Peabody Museum. After a general review of the methods of ornamentation employed by American nations of the past, he showed that, by a study of such large collections as those in the Peabody Museum, the artistic development of the ancient peoples of America was far greater than generally stated by writers; and that the art of ornamentation had, in many instances, risen above the simple patterns made by incised lines, rude stamps, and other early and crude forms. Both in color and plastic work a realistic art had been produced which had often resulted in conventionalism of great interest. He also stated that a study of this ancient pottery, with these principles of conventionalism borne in mind, would not only place some of these ancient American nations in a much higher artistic period than formerly supposed, but would also lead to the understanding of many of the singular ornaments on ancient vessels, many of which, without this knowledge of the existence of realistic and conventional art, would be looked upon as crude and meaningless attempts at ornament, whereas, as he showed by several series of specimens, the simple knobs arranged symmetrically about a pot or water bottle, were instances of pure conventionalism from realistic forms, and prove that a comparatively high attainment in the decorative art had been reached. A proper and careful study of the principles involved by this interpretation of the artistic development of the ceramic art in America, he thought, would in time furnish means of making comparisons in regard to the probable connection of one ancient American nation with another, and also an understanding of many of the singular resemblances between widely separated peoples. Still, he said, the whole subject was yet in its infancy, and the connection of one ancient people with another in America can at present only be suggested from very unsatisfactory data.

## DESTRUCTION OF THE PYRAMIDS.

A CORRESPONDENT of the *Egyptian Gazette* writes: "I have just returned from a most interesting series of excursions to the Pyramids. They were made from a dahabiah, and included visits to the great pyramids of Gheezeh, at Sakkarah, to Dashoor, and to Maydoon. I regret to say that in several places we observed the hand of the destroyer at work. Not only was this the case at a remote place like Dashoor, but, so to speak, under M. Mariette's very nose. Some four or five large stones, immediately under the entrance, have been removed from the Great Pyramid; and, incredible as it may seem, I was informed, on what seemed to me trustworthy authority, that this wanton act had been committed by order of the Khedive, the stone being required for the buildings of the new mosque which so greatly overshadows the beautiful mosque of Sultan Hassan. Few people would be sorry to see the hideous new building pulled down, but that the pyramid should be further destroyed to build it is one of the most singular examples of the 'revenge of time' I ever heard. It is well known that, beautiful as is the mosque of Sultan Hassan, we have it at the sacrifice of the Great Pyramid, which was pulled down to build it. That the Great Pyramid should, after the lapse of more than five centuries, be once more put under contribution, and that for the purpose of building a mosque which already, when only half finished, hides and dwarfs its older neighbor in a way almost destructive of the pleasure of looking at it, is, indeed, a noteworthy example of the vicissitudes of fate and the irony of history. When the Government itself sets an example of this kind, we are not surprised that it is promptly followed by meaner folk. At Dashoor, a place seldom visited by the tourists, and where consequently the marauder thought himself safe, three camels were during our stay being loaded with the square white limestones of the casing of the larger pyramid. Few of these stones remain. The upper part of the pyramid has long been stripped. But, in spite of the remonstrances of our party, and the threat, promptly carried out, of a complaint to the Government by letter, these few relics were being ruthlessly pulled away, every removal of a stone insuring the destruction of two or three of its neighbors. The adjoining pyramid, which is so conspicuous from Helouan, and so remarkable from being built in two different slopes, had till lately its casing nearly complete. This casing is of the greatest importance, for the alteration of the angle will almost disappear when it has been removed; and I regret to say, though I did not actually see the work in progress, there can be no doubt that here also the destroyer has been recently busy. Stones, loosened from the top of the building, have been rolled down the side, tearing and smashing the smooth surface. Three or four large stones have also been removed from below the entrance, which is now inaccessible without a ladder. It is in little-known places like Dashoor that such destruction as I describe is most easy to perpetrate and most difficult to prevent. But there cannot be much difficulty in watching the Great Pyramid of Gheezeh."

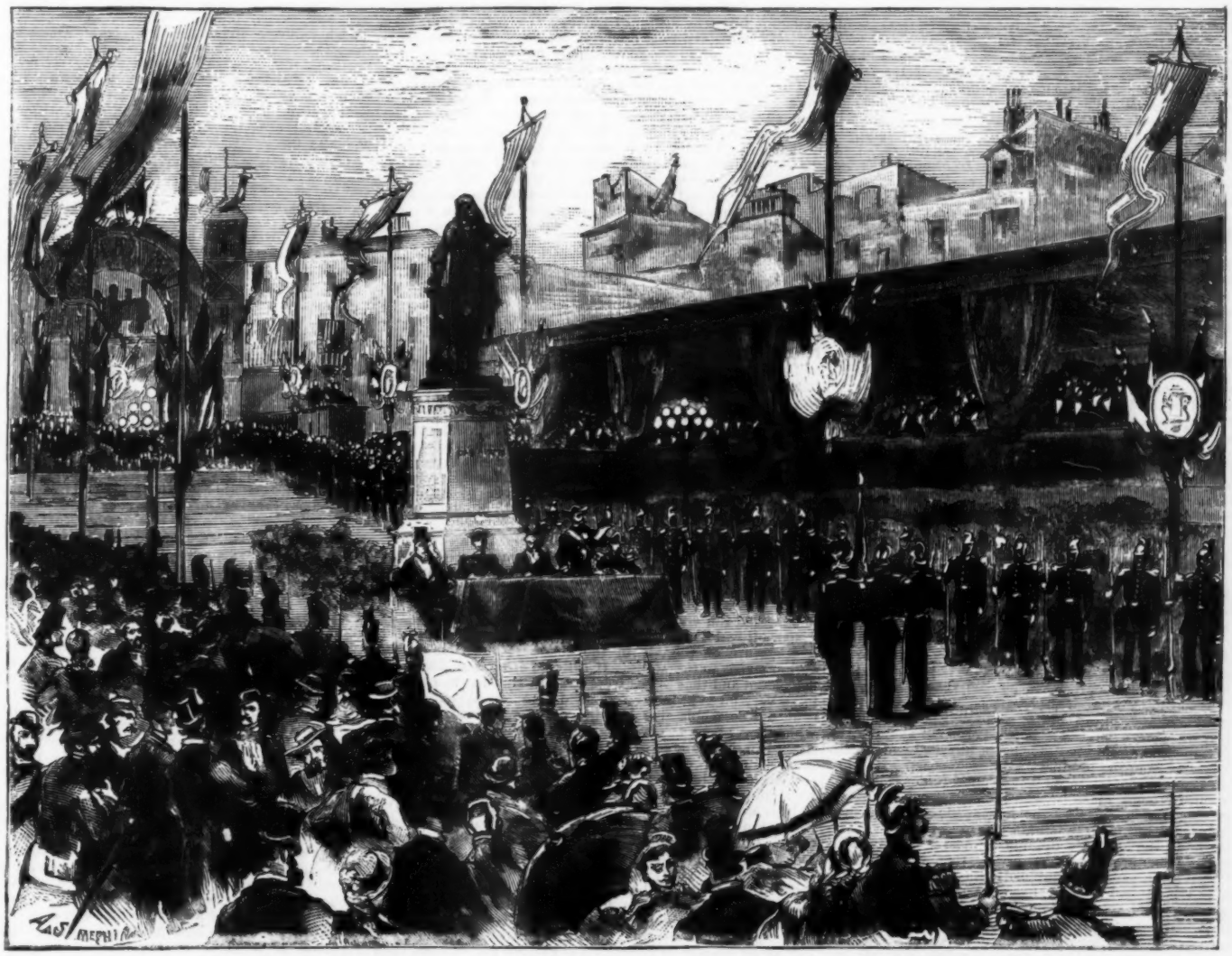
## BURMESE OIL WELLS

AT an ordinary meeting of the Geological Society of Glasgow, an interesting paper was read on "The Oils and Oil Wells of Burmah," with a notice of the more salient geological features of those parts of the country over which petroleum or earth oils have been found, the author being Dr. James R. M. Robertson, of Renfrew, a gentleman who is well known as a mining explorer in the "far East." After giving an outline description of the great range of country embraced by Burmah and the territories immediately surrounding it, and noticing the deposits of metalliferous minerals, the geological features of the country, etc., the author proceeded to deal more particularly with the soft sandstones and arenaceous shales, and remarked that, in the absence of distinctive fossils or positive characters by which the rocks might be identified, it was difficult to assign them to any particular series or age in the geological record.

On the west coast of Burmah there were two islands, specially known as Cheduba and Ramri, and the Barongah Islands—the latter being a group of three. These were specially referred to as having mud volcanoes scattered over them, and as having been known for ages to yield petroleum. In some parts along the coast gaseous hydrocarbons escaped under high water mark, and could be inflamed on coming to the surface. During violent eruptions of the mud volcanoes there were occasionally large quantities of gas emitted, which, in some recent instances, had caught fire and had illuminated the country for many miles around. It was noticed that these violent eruptions were always synchronous or simultaneous with earthquakes passing over adjoining countries. There were similar emissions of gas observable from the mud volcanoes of Java, at Baku (on the Caspian Sea), and near the Sea of Azof. But when the volcanoes in question were in a state of quiescence, bubbles of gaseous hydrocarbons continued to issue from the vent.

In Pathar, in Assam, there was a certain hollow, that contained many muddy pools in a state of constant activity, which threw out white mud mixed with petroleum. The petroleum of Cheduba, Ramri, and the Barongah Islands was of a light specific gravity, of a mahogany brown or brandy color, containing a very large proportion of burning oil, and almost no solid paraffin. Oils possessing the same physical properties and chemical composition were found in the Punjab and Beloochistan, in the vicinity of long dormant mud volcanoes, and on the shores of the Red Sea below Suez. On the western islands of Burmah the oil was collected in shallow holes or wells, from which it was periodically drawn off. In Cheduba and the Barongahs the holes were quite shallow, but in Ramri certain groups of wells had been sunk to a depth of from twenty to thirty feet before reaching the stratum of rock from which the oil was got.

As a rule, however, even in Ramri, they were mere surface pools. Only an insignificant quantity of oil was obtained in the pools or wells, ranging from two to five bottles per day. The wells were not evenly scattered over the surface of the ground, but were grouped together in those situations where the oil was yielded. So far as was yet known—and certainly the result of all the author's investigations had convinced him that, saving the appearance of the oil itself, there were no positive signs or indications



INAUGURATION OF PAPIN'S STATUE AT BLOIS, FRANCE.

by which an observing man could prognosticate, or determine, or fix on sites as those likely to yield a supply of oil. The oleaginous spots were eminently capricious and partial, and were determined by causes as yet unknown. In the latter part of the year 1877, two English companies began to explore the Barongah Islands for petroleum, being convinced that the appearance of the hydrocarbons on the surface betrayed a deeper origin, and large reservoirs of oil in the depths. Both companies resorted to boring. At the date of Dr. Robertson's arrival at Akyab, the bore hole in one instance had reached a depth of 260 feet, having passed through successive beds of "chucky" sandstone and arenaceous shales or clays containing calcareous nodules. Some of the beds were supposed to smell faintly of oil.

In the other case, two pits thirty feet in diameter had been sunk to a depth of thirty feet, and in the bottom of each a bore hole had been sunk. On reaching a total depth of sixty-eight feet from the surface, and after piercing a firm bed of calcareous clay, the bore holes evidently struck a fissure containing pent-up gases. On being tapped, the gases rushed up the bore hole with violence, and were followed by oil. About 500 gallons or so per day were obtained during the first week, after which the quantity diminished to insignificant proportions. That was the only instance within the author's knowledge in which oil in those regions had been struck by a bore hole and had risen to the surface. (It had lately been reported that other flowing wells or bores had been tapped, but the author was doubtful of the accuracy of the report.)

In the case of the shallow holes made by the natives, the supply had existed for centuries, without, it was affirmed, any apparent or appreciable diminution. The supply might be taken, in short, to represent the rate of elaboration, or the rate at which the formative process went on. In the case of the slightly deeper wells, however, the yield, which at first was greater than in the surface pools, was, as a rule, liable to diminish, and in all cases where the depth of the wells was affected by the prevailing temperature, or where they were within climatic influences, the supply was intermittent —the yield in such cases being greatest just after the hot season and during the prevalence of the monsoon rains.

After some further remarks, Dr. Robertson proceeded to speak of the eastern extremity of the oleaginous zone of rocks within which earth oils had been found, the country referred to lying to the east of the Arrakan Mountains, and being wild and innocent of roads. He described the geological features of the region in question, laying particular stress again upon the soft sandstone rocks met with; and he remarked that by exposure to climatic agencies through a long period of time those rocks had been worn and scooped out into innumerable ravines, an interminable succession or network of nullahs, that were only separated from one another by steep and narrow spurs. Sometimes a few of the nullahs coalesced, and a level part of limited extent was formed. The ravines, as a rule, were from fifty to seventy feet deep, and in the lower part the underlying clays were exposed.

In one of the ravines, or nullahs, about eleven miles from Thayetmyo, and within a mile and a half of a Burman village named Pidouhbeng-Yua, appearances of earth oil had been discovered some years ago; and, previous to the author's arrival at that place, four wells had been sunk on the lower part of the steep slopes of the ravine, to a depth of from thirty to forty feet, through the yellowish sandstones and arenaceous and calcareous clays, into a bed or stratum of (when fresh) greenish, coarse, and partially consolidated sand, on piercing which the oil exuded in limited quantities. In a thickness of almost 500 feet of strata proved at this place there were at least three distinct beds of the greenish or yellow coarse sand, at various depths, and containing more or less oil, but always in small quantities. Such beds were called "kabaa," a very expressive Burmese name. The upper oil stratum or kabaa yielded by far the greatest quantity of oil, the yield of the lower seams being found to be insignificant. The oil was contained in the porous sandstone as in a sponge, and from it, when pierced, the oil slowly exuded, not—as in the case of the western islands—as a thin, mahogany colored liquid, but as a thick, greenish colored liquid, containing a large percentage of solid paraffin, of pleasant smell, and entirely differing in physical and chemical properties from the product of the west coast. Its only point of resemblance lay in its being found under similar or almost similar conditions.

Overlying and underlying the kabaas there was a firm layer of arenaceous clay containing calcareous patches. The clays were, in the author's opinion, almost impervious to water, and, when brought to the surface, they were perfectly dry. That circumstance, combined with the different properties of the oil, and the fact that it was only found in the soft porous sand, early raised questions and speculations in his mind as to the origin of the product, and at this stage he discussed at some length the alleged sources of the oil, both from the geological and chemical points of view; but none of the explanations that had been given were satisfactory to him.

Speaking again of the wells near the Burman village previously mentioned, he said that after the first monsoon rains had fallen the yield of oil from the top kabaa greatly increased in amount, and the increase was not accompanied by any increase of water. The amount of the increase varied in the different wells from three to six times more than that drawn during the dry, overpowering heat of the hottest months. In order to obtain some information that might be turned to good account in his investigations in Lower Burmah, Dr. Robertson proceeded to Upper Burmah to inspect the King's wells, which for centuries had yielded very large quantities of oil. He proceeded up the river Irrawaddy till he came to Yeynan Choung—a name which signifies earth oil creek—the shipping place of the oil drawn from King Theebaw's wells. As the steamer approached the place the smell of petroleum was perceived to fill the air. A fleet of cargo boats had it in bulk, and acres of great earthen jars containing it lined the beach. The wells were situated a few miles inland, and reached by an almost impassable track.

Beyond the limited but extremely picturesque patch of fertility surrounding the town there was a region of perfect sterility as far as the eye could reach. Here they lived a rough and ever watchful life within the high stockade of the Indian Mohammedan who farmed from the King the whole produce of the wells. Dr. Robertson gave a description of the geology of the ground over which he and his party traveled inland from the Irrawaddy, after which he said that by and by they arrived at a point from which they could look down upon the famous Tongune oil wells "of the master of many white elephants" and the "great king of righteousness." There were about 800 wells, occupying the top of a broad ridge between two parallel ravines, the space over which they were scattered being oblong and not exceeding 500 acres in extent. It was not very clear why the area of the oil bearing rocks should be so strictly defined as was seen to be the case, for, according to the natives, no oil had ever been found beyond the lines of the two ravines. To the east and west the ravines were about sixty feet deep, and had all but perpendicular sides.

Large quantities of oil were yielded by the wells that were sunk all along the inner cliffs; and on the opposite cliffs, at about fifty or sixty feet from the working wells, there were seen the remains of several old wells, which had been sunk to the kabaa, but they gave out no oil, while not a single well existed beyond the line of the choungs or ravines. A few abandoned wells were also seen on the surface to the north and south, which had been sunk to the kabaa in the expectation of proving a continuation of the oil kabaa. But they did not prove its continuity, as it became thinner and of a harder consistency, and instead of oil it gave off water. Over the uneven surface of about a square mile, under which the deposit extended, fully 1,000 wells had been sunk, of which about 800 were capable of yielding oil, although at present, from the lessened demand in British Burmah, consequent on the large importation of the American product, and from the state of disrepair into which many of the wells had fallen, there were not more than 280 wells being worked. Roughly speaking, the wells were for the most part grouped along the margins of the ravines.

It was believed (and, the author thought, the natives were justified in believing) that if all the abandoned wells were cleaned out and re-sunk they would again become oil-yielding wells. That, however, even with appliances for producing ventilation, would be a difficult operation, as, from the abundance of gas given off, no lights could with safety approach a yielding well. Within the oil district the working wells did not yield a drop of water; a few yards beyond the arbitrary boundary line, however, wells sunk to the same position gave off an abundant supply of water, which, as a rule, was charged with sulphureted hydrogen gas. The oil-yielding stratum had a thickness of about five feet, and in its composition it was loose and incoherent. It was highly charged with oil, which oozed out whenever a fresh piece was placed on the ground. When the oil kabaa was pierced, gas and oil issued freely, but with no force or pressure, the oil exuding as water would from a freshly charged sponge. It never rose more than a few feet. If a group of wells closely placed together were worked simultaneously, the yield from each well was appreciably less than if one-half of them were stopped. For that reason the drawing wells were now spaced about forty yards apart.

The production varied from 500 to 1,000 vis per day per well, a vis being equal to fully one-third of a gallon; it might, therefore, be said that the yield ranged from 200 to 400 gallons per day. There were some wells that yielded from 500 to 700 gallons per day for the first three years, and yet others by which they were surrounded did not give one-fourth of that quantity. One well was specially pointed out to Dr. Robertson that had yielded 700 gallons per day for a number of years, after which the supply diminished gradually until it reached 130 gallons, which quantity it had yielded daily for the last eighteen years. In some places the average depth was about 320 feet, in others upwards of 400 feet, and in others it decreased to 200 feet, and even to 120 feet. How one well, surrounded by twenty or thirty others, should give five or six times more oil than those adjoining, would, the author thought, only be satisfactorily explained when a clew had been discovered to account reasonably for the production of the oil itself.

There were three qualities of oil obtained from the wells: (1) Yeynan Ghee, or butter of oil; (2) Umbawn; (3) Kagathee. They all had a dark green color, were thick and viscid in consistency, and became almost solid at a temperature of 60° Fahr. or under. The odor was pleasant and not strong, and the specific gravity was about 0·810. Newly drawn oil had a temperature of about 88°, or 26° under the temperature of the air in the shade at the time of the author's visit to the wells. It differed from the American petroleum and that of the west coast of Burmah in containing a very large proportion of solid paraffin. About 71 per cent. of the whole was burning oil, the flashing point of which was about twenty degrees higher than that of the American oil, while in every respect it was a superior and more valuable product. At the time of Dr. Robertson's visit —sixteen months ago—the quantity of oil drawn from the wells under notice was 6,000 gallons per day, which was said to be scarcely one-half of what the wells could produce. Dr. Robertson subsequently visited another oil-yielding district called Bhaema, about three miles south of the Tongune wells, and where, from very ancient times, oil had been obtained under precisely similar conditions. There were upward of 200 wells in the district, which was shown to be quite as peculiar in its physical characters as that previously noticed. About eighty were working at the time of the author's visit, and the total yield was about 2,200 gallons per day, or an average of twenty-eight gallons per day for each well. Another oil district was referred to by Dr. Robertson as occurring about thirty miles further up the river, and ten miles inland, but he did not visit it, as his movements had now excited a certain amount of suspicion.

## A CLEW TO THE WORLD'S HISTORY FURNISHED BY A WEED.

KERGUELEN'S LAND, in the far South, is little else than a succession of hills and mountains formed almost exclusively of volcanic rock. The island lies some 4,000 miles to the west of the southern extremity of South America, and is one of the most barren tracts on the face of the globe. Such a tract might not appear very promising to a naturalist, but the result proves quite otherwise. No tract is devoid of interest to the well-informed, observant naturalist, and the natural history of Kerguelen is, as will presently be seen, of great importance, as furnishing a clew to the past history of the world. As to the flora, Dr. Hooker has shown, in the Transactions of the Royal Society, that it possesses one endemic cruciferous plant peculiar to the island, the "Kerguelen cabbage" (*Pringlea antiscorbutica*), which has no near ally; one endemic genus allied to an Andean one; six endemic species allied to American congeners; five species common to Fuegia but not found elsewhere; six species common to America and New Zealand and the islands south of it, most of them being aquatic or marsh plants; two species found elsewhere, but not in Fuegia. The American affinity of the Kerguelen flora is even more clearly shown by the flowerless plants, among which, however, the only evidence of migration from South America occurs. This is the case of *Polypodium vulgare*, a widely distributed fern in the north temperate zone, but known in the southern only from Cape Colony, Marion, and Kerguelen islands. Granting that the majority of the Kerguelen plants come from South America, 4,000 miles distant, how was their transport effected? The usual means of transport by birds, winds, currents, etc., and the facilities offered by the structure of the plants themselves, are insufficient to account for the phenomenon, so that the only hypothesis left is the assumption that more land formerly existed between Kerguelin and Fuegia, and which has since disappeared. There seems to be evidence to support the supposition that the three archipelagoes, Kerguelen, the Crozets, and Marion, have been peopled with land plants from South America, by means of intermediate tracts, which have now vanished, and that these islands now constitute the wreck of an ancient continent which formerly extended further westward, and that their present vegetation consists of the waifs or strays of a mainly Fuegian flora, together with a few survivals of an endemic one. The existence of this ancient land-connection, first suggested by Sir Joseph Hooker, was independently enunciated by Mr. Moseley, who found the "Kerguelen cabbage" on Marion Island, as also on the Crozets and Kerguelen; and he shows how this fact points to an ancient land communication between these islands, since the seeds of this plant are very perishable, and not adapted for transport, while the distinctness of the floral structure, differing from the rest of the order, points to a former wide extension on which its progenitors became developed. These ideas, suggesting the hypothesis that the existing distribution of plants is dependent on former geographical relations of the land and sea, occurred to Sir Joseph Hooker in 1840, on his visit to Kerguelen; and it is a matter of no little interest to see how an obscure weed, which most persons would pass by as a cabbage, and nothing more, should have been the means of originating an hypothesis as to the history of the globe and the genealogy of its vegetable inhabitants, which succeeding discoveries in geography, geology, and botany serve to confirm. This *Pringlea*, or Kerguelen cabbage, found, as before stated, nowhere but on these three islands, has a thick root of great length supporting a tuft of large fleshy leaves, like the open cabbages of our gardens. Its flower stems are two to three feet high, the petals are wanting. Most of the Crucifers, as well known, are insect-fertilized, the bright flowers and the nectary-secreting glands serving to attract insects; but in *Pringlea* the petals and the glands in question are wholly or nearly wanting. Relying on this circumstance, and on the facts that the anthers are protruded beyond the flower, and the stigma is provided with long tufted papillæ. Sir Joseph Hooker came to the conclusion that the pollen was conveyed to the stigma by the wind. In connection with this is the curious fact that up to the present time no winged insect has been found in Kerguelen, though wingless flies abound on this very plant.

## MEASLES.

Lecture delivered by ALONZO CLARK, M.D., LL.D., Professor of Principles and Practice of Medicine, College of Physicians and Surgeons, New York.

I CALL your attention now to another of the eruptive diseases—measles—a disease so mild in many cases that the family do not call a physician, and yet so severe in many as to make a pretty large mortality in a city like New York. You will be surprised, perhaps, to hear, if you know anything about the course of measles as it most commonly presents itself, that the mortality here is two, three, or four hundred a year, varying very much; down below a hundred many years, and up to two or three hundred, or more, some years. The explanation of this lies partly in the fact that measles is a more prevalent disease than scarlet fever. If you look into the medical register, or any medical journal that reports the number of contagious cases that occur in the city week after week, you will see almost invariably that measles is two or three times ahead of scarlet fever in the number of cases.

It is, then, sometimes a very grave disease; at other times a very mild disease. I will describe it to you in the same manner that I did scarlet fever by marking the several stages.

It is only to be had by contagion. It does not arise *de novo*, even from decomposing oat straw! A Western physician made this a source of measles for the young members of the army in the late war; but there is no good ground for the opinion that I can see. Measles is obtained from measles, and from nothing else.

The period of incubation is not definitely fixed. Indeed, it *is* fixed, and we have ascertained that it is *irregular;* that it is uncertain. As an example, Dr. Buell, who lived in New York a good many years ago and moved to San Francisco, recited to a medical society his experience with reference to a house down town, in College Place. College Place was then a place of residence; it is now a place of stores. At a boarding house there a lady with two or three children was so unfortunate as to have measles break out among them. As soon as it made its appearance the boarding-house mistress, conscious that it would injure her business by causing other boarders to leave, required this one to go out of the house. The room was left unoccupied for a week, when another family came in to occupy it with children also. In seven days from the time they entered that room measles broke out in the family. The landlady drove this family away and another took its place, and in seven days after the third family came in measles broke out among their children, so that for two particular instances seven days was the period of incubation. But there are other instances that can be quite as well marked in which it goes on to eight, nine, ten, or even to fourteen days. The period is given very variously by the different persons who have written about the disease. As for example, Holme makes it from seven to fourteen days, Williams, from six to sixteen days; Rilliet and Barthez, five to thirty, and even fifty days; and they are very good authority. Their statements are received as statements made on careful observation.

I should doubt very much whether it has an incubation of fifty days; at the same time I cannot limit possibilities in the matter.

When, then, it makes its appearance in different persons, at a variable period after exposure it has its stage of invasion, and this is pretty long for an eruptive disease; the longest of them all, three to four days. It is rarely ushered in with a chill, though cases are recorded in which a chill did occur as the first symptom. There is commonly, before anything very marked is observed, an indefinite feeling of not being well; *malaise*, as the French call it. And then comes a little febrile action, which increases day by day, and with that febrile action a redness of the eyes, and a little watery condition of them. The tears are secreted, and then there is the extension of the inflammation that was at first confined to the membrane of the eyes. On the outer membrane of the eyes it extends into the nose and into the

fauces, and so down gradually into the breathing tubes. You have, in a word, a catarrh, and the catarrh, when it is fairly formed, is attended by a peculiar cough in most of these children. The French have called it the "iron" cough; a harsh, coarse cough. The eyes run a good deal; the nose is a little busy in that same business. There is some headache; the temperature is elevated moderately, and this condition continues for a period of from three to four days. The invasion of smallpox is two days; the invasion of scarlet fever from six or seven hours to twenty-four; the invasion of measles three to four days. The child is not very sick during this period of invasion, as a rule; though, as I told you, there is considerable fever, the temperature rising to 103°, or it may be 103°.

Then comes the eruption. The eruption appears upon the upper part of the body first, and gradually descends to the lower part, just as scarlet fever does in the majority of cases, and yet there are exceptions. Measles may break out all over the body, or it may break out upon the back first, but the general rule is that it appears upon the neck and face first, and gradually descends. It takes it about two days to reach the feet in the greater number of instances.

The character of the eruption you may get an idea of from this portrait, and notice particularly the condition of the eyes. They are red, and so are the fauces and the bronchial tubes and the nasal passages—all reddened by this catarrhal inflammation. This eruption is sometimes called crescentic. I believe this is a fair representation of it, and you will hardly find a crescent in any of these spots of eruption. It is better described as being irregular in shape, varying somewhat in size, but rarely larger than a bean—sometimes in some degree linear and curved, but always varying. Every particular case of measles will give you a multiple form of eruption; it does not occupy, as the scarlet fever eruption does, all the skin. There will be healthy skin along between the several spots; red eyes, and a peculiar eruption of a dingy color, not bright red. The eruption lasts in any one spot about four days, and the whole eruption about six or seven days, it disappearing on the feet after four or five days of continuance, as it does upon the upper part of the body in the same period. You observe there is no difficulty in distinguishing the eruption of scarlet fever from the eruption of measles. They are both produced by numerous slightly-elevated little points, the loops of the capillaries of the skin, but the irregular patches of measles and the darker hue of the eruption are sufficient to distinguish it from the continuous eruption of scarlet fever.

In a mild case, as in scarlet fever, the fever gradually diminishes after the eruption appears, but in a bad case the fever continues and the temperature rises. The bad cases are made by certain complications. As for example, there is the hemorrhagic form of measles, in the old time called black measles. The patches take on a dark, ecchymotic color—not so marked as ecchymosis, but still approaching it. In this case, as in the hemorrhagic cases of scarlet fever, the danger becomes very great, and the chances of recovery, of course, are diminished. In certain other instances there is a tendency to gangrene, particularly about the mouth; and in the female, the vagina, and sometimes the anus. And this gangrene comes to be a very grave matter. It is exceptional, fortunately.

Then, again, you have a form of measles that resembles, in its general symptoms, that form of scarlet fever I described to you under the name of scarlatina maligna. The child appears to be overwhelmed by the poison that produces the disease. The nervous system seems to give way. He becomes delirious and comatose, perhaps awakening occasionally from his coma, making a shriek, a hydrocephalic cry, though there is no hydrocephalus.

You observe, then, that measles, though in a greater number of cases a very mild disease, can take on very grave symptoms.

When the period of desquamation occurs there is a noticeable difference between the desquamative scales of scarlet fever and measles. They are branny in measles, and branny for the most part in scarlet fever, but the scales are larger in scarlet fever than in measles, as a rule. Sometimes in measles you have it in great quantities. I have scooped it up in teaspoonfuls from the sheet on which the patient lay. There is nothing of the glove-form of exfoliation in measles.

There is, as a sequela of measles, a very considerable amount of ozæna, as it is sometimes called—a bad catarrh; running at the nose; the eyes retain their redness frequently for a considerable time; the cough holds over, and may continue for some months. And persons have been known to pass into phthisis, tuberculous disease of the lungs, out of measles.

As to the treatment of measles, the mild cases hardly require any. The catnip tea that the mother gives is as about as good as anything. And when you come to the severe complications you are baffled very much, because you can hardly find anything that will have much influence over it. If it is the hemorrhagic form, why, then, iron and the vegetable acids, together with the supporting effects of quinine and food, will probably do more for you than anything else, if you can save the case at all. If it is attended by gangrene, there is nothing that has as good a reputation as quinine, and you, of course, support the power of the patient by alcoholics as far as your judgment will require. In the malignant form I do not believe you will find any medicine do much good. If ergot has the control that it has the reputation of having over the capillary circulation, it may be possible that it may have some effect upon this form of disease. It has not been tried, so far as I know, and I do not know that it would be useful. Cold to the head, cold to the body as the temperature becomes more and more elevated, is certainly admissible and desirable to reduce the temperature to a safe point at any rate; and in measles the temperature rises in the bad cases sometimes to 106° or 107°.

There are a few things more to be said regarding measles. I neglected to say to you that another name for it is morbilli. Among the symptoms is rather a curious one; an odor like that which comes from the nest of mice—a mouse-odor. In any case of pretty full eruption you will be likely to find it.

Among the sequelæ will be found, not unfrequently, indeed pretty commonly, a certain amount of nasal catarrh, and this may continue for some weeks after, and associated with that, very commonly, is a pulmonary catarrh. One of the features of the disease, and with its early development, is this catarrhal affection of the mucous membrane of the eyes, nose, and breathing tubes, and this holds over in a considerable number of cases, and not unfrequently gives some anxiety, and the anxiety is in a few cases well founded, for this disease and typhoid fever are followed more frequently by phthisis than any of the other acute affections that I know—by a tubercular phthisis. Still the vast majority of persons who have measles recover from it wholly.

This ophthalmia is sometimes the occasion of some trickery. I was, a great many years ago, in company with a gentleman from the South. His eyes were red and inflamed to a certain extent, and I saw at once that it was a peculiar relic of the measles. After dinner the entertainer's son asked me what that young gentleman had better do for his eyes. He had been to an advertiser, and the advertiser had informed him that it would cost him $500 to be cured, and the friend asked me whether it was worth while to pay it. When I learned who it was that he had applied to, I told him certainly not, but to go to Dr. Delafield, the father of my colleague (who was then giving considerable attention to the eyes), and let him put him under the regular treatment. He had sent word to his father to forward him the $500 as a fee that he had to pay to cure his eyes. Instead of it, however, at my advice, he went to Dr. Delafield. Dr. Delafield applied around the eyes some veratrum ointment, and in five, six, or ten days, he was all right, and the fee was $19. This advertiser had tricked him in this way. When he urged that $500 was a large sum to pay, the advertiser replied: "The medicine is so expensive. You get the medicine and I will treat you for very much less." He gave him, therefore, a prescription for an ounce of veratrum, which at that time cost about $500. He called on one druggist with the prescription. The druggist said: "I have not that amount, but I can procure it for you." "Well, what will it cost?" "Four hundred and seventy-five dollars."

He went to another, and what would it cost? He had not that quantity, but he could get it for him. What would it cost? Four hundred and eighty dollars. And, after trying three or four times, he went back to the advertiser and said he could not do any better, and the advertiser was getting ready to use a few grains of this ounce that he had prescribed.

Occasionally wry-neck follows measles. The muscles of the neck get stiff and contracted, and turn the head. That is rather a wearisome thing when it occurs. It occurs exceptionally, and frequently requires a good deal of patience on the part of the physician, and I cannot tell you of any particular prescription or any method of treatment that is of special aid.

Anasarca not unfrequently follows scarlet fever. It is a very much less frequent sequela of measles, and yet it does from time to time occur, and acts in the same way, with the same symptoms, the same developments with reference to the tendency to convulsions, the tendency to the production of inflammatory action, particularly about the heart and pericardium, and will require the same treatment. But its unfrequent occurrence will give you a little satisfaction. That is, as you are coming to the end of a case you will not consider that, as a matter of course, this œdema or anasarca is to occur.—*Medical Record.*

## INJURY OF THE CORNEA BY A FOREIGN BODY.

From a Clinical Lecture by CORNELIUS R. AGNEW, M.D., College of Physicians and Surgeons, New York.

OUR next patient is a gentlemen who, one week ago tomorrow, received an injury to the cornea of his left eye from a foreign body. Dr. Webster tells us that yesterday he removed a foreign body from this patient's eye. His eye now looks red. The blood vessels which are unduly filled are located near the inner canthus of the eye, in the conjunctival tissue. By looking sidewise at the eye we are enabled to tell, even with very little experience, whether the deep or the superficial vessels are the ones which are seen most prominently. In this case you can see the vessels branch in the layer of tissue immediately under your eye. By taking a probe with a little cotton upon the end of it, and, having dipped it in water, touching the tissue in which the vessels run, you will find that you can push it from side to side. You should learn in the examination of all diseased conditions of the eye to determine exactly in what tissue the abnormal condition exists. You should turn over in your imagination the various layers of tissue, as you would the leaves of a book, and in this way after a while you will be able to tell at a glance whether the inflammation be superficial or deep. If you will look at the lower edge of the cornea, you will see a little grayish abrasion, and that is the place from which the foreign body was removed. Now, suppose a case were brought into your office such as this was yesterday. Is any gentleman here prepared to tell me how he would proceed to remove it? One suggests a magnet. That is very good. But suppose you have no magnet? I will tell you of a very good method—one not usually described in books. Take a little stick, place upon one end of it a small pledget of cotton, and, after having moistened this, brush it over the surface of the cornea at the point where the foreign body is, and it will very likely be caught in the fine meshes of the cotton. Having prepared such a probe, the eyelid is drawn up against the superciliary ridge and the eyeball kept from rolling. Then, seeing exactly where the foreign body lies, you quickly brush over the surface, so impinging the cotton against the surface as to cause the foreign body to have a tendency to rise into it. In this way you may remove all foreign bodies not deeply embedded. If you do as is often done, namely, pick at the foreign body with a cataract needle, you may not get it out, and by your picking you may cause a great deal of pain. So I would recommend you to follow the directions which I have just given, which will answer in all ordinary cases. Suppose, however, that the foreign body is so deeply embedded that you cannot get it out by means already cited, you can then take a cataract needle or a Bowman's spud so flattened at the extremity that it may be passed under the foreign body and tend to lift it out. You must be exceedingly careful not to injure the cornea, for that will impair the vision. Suppose there is a little mass of steel embedded in the cornea, and you can see that it has gone through the cornea, so that the point of the steel is in the anterior chamber, and when you try to remove it you see a little leakage of the aqueous humor, then what should you do? You must get something back of the foreign body, or it will fall into the anterior chamber. You can do this by means of a Beers knife and under the influence of an anæsthetic. The eyeball should be steadied with a pair of fixation forceps, and the knife placed about a line from the body and perpendicular to the cornea. It should be carried right through the cornea into the anterior chamber, and then the blade of the knife turned and the handle depressed, so as to bring the point of the knife out beyond the foreign body, thus preventing it from falling into the anterior chamber. Thus you have the foreign body lying held in the cornea. It lies spitted upon the knife. I think I have been enabled by this method of procedure to pick out more than one foreign body and save the patient's eye.

### EYE STONES.

Now, I do not think that eye stones are of any value in removing foreign bodies from the eye. The only way they act is this. They are disk-like masses which tend to pass over to the inner canthus of the eye and there to discharge themselves. The advantage that the eyestone is supposed to have is that it elevates the lid and allows the tears to wash the foreign body off from the surface of the eye. That might be an advantage in cases where simply a cinder got behind the upper eyelid, but this means is of no value in cases where the foreign body is embedded in the cornea. It is a very bungling method, and I never use it. Now this man here will get well in a few days, I think. I would recommend that he keep the eye quiet and protect it as well as possible. The only thing I would use in the way of a wash would be a little table salt in a little warm water, say a teaspoonful to the pint.—*Medical Record.*

## APPLICATIONS OF ARTIFICIAL COLD IN INDUSTRIAL CHEMISTRY.

No fact is more familiar to scientific men than that the behavior of substances brought in contact is powerfully modified by the temperature to which they are submitted, the results produced being affected not merely in degree, but sometimes even in kind. But while in manufacturing operations temperatures ranging from the average heat of the atmosphere up to the melting-point of platinum have stood at the disposal of the technologist, and have been applied as requisite, it is only of late that what is familiarly known as *cold*—*i. e.*, temperatures below the freezing point of water—has been made available on a practical scale.

The following examples will at least show that the freezing machine, as the antipodes of the furnace, has a future before it of which inventors will do well to take heed:

### PRODUCTION OF SODIUM SULPHATE—GLAUBER'S SALTS.

M. Georges Fournier, of Paris, has devised a method for obtaining sodium sulphate, commonly known as Glauber's salt, depending on this novel industrial agency: In various parts of France, especially in the neighborhood of Rheims and in Picardy, there occur extensive deposits of pyritic shales far too poor in sulphur for use in the kilns of sulphuric acid works, and only occasionally utilized in the manufacture of copperas and of alum. But now the latter product is generally prepared from china clay, or from bauxite, and now the works at La Tolfa have been revived by means of French capital, and are sending to France and elsewhere large quantities of the much esteemed "Roman alum," the makers of alum from pyritic shales—despite the cheapness of their raw material—find themselves driven out of the market.

The problem, then, which M. Fournier undertook to solve is this: How are such shales to be utilized, and especially how can the sulphur which they contain be made to effect the decomposition of common salt and the production of sodium sulphate?

He takes the shales in the state in which they were formerly used by the alum and copperas makers. On prolonged exposure to air, namely, the sulphur of the pyrites becomes oxidized to sulphuric acid, and, attacking both the iron and the clay with which it is intimately associated, it forms a mixture of iron and aluminum sulphates. The shales are then lixiviated with water, and as the solution generally contains an excess of acid it is neutralized, as far as possible, by being allowed to stand in contact with scrap-iron. Being then run off into crystallizing tanks a very considerable quantity of copperas is deposited. So far, it will be clearly understood, M. Fournier is merely following in the footsteps of the manufacturers of copperas and alum. But now comes the new feature of the process. After the copperas has been deposited, the mother-liquor, containing all the aluminum sulphate and a portion of iron sulphate, is run off, and mixed with common salt in such proportions that there may be sodium enough to combine with all the sulphuric acid, and chlorine enough to take up all the aluminum and the iron. The mixed solution, which should not exceed 23° Baumé in specific gravity, is then exposed to a temperature of —2° to 3° C. In what manner this temperature is produced is a matter of indifference as far as the principle of the invention is concerned. When I saw the process worked on the large scale at the establishment of M. Raoul Pictet, in La Chapelle, the sulphurous acid freezing-machine was used with very good results. In a short time double decomposition takes place, and we have in solution—instead of sodium chloride and aluminum sulphate—sodium sulphate and aluminum chloride. As, however, at temperatures bordering on and a little below 0° C., sodium sulphate is almost insoluble, it is deposited in the state of a fine crystallizing sediment of the decahydrated salt (the ordinary form of Glauber's salt) while the aluminum and iron remain in solution as chlorides. The mother-liquor is rapidly run off, and the deposit is freed from the chlorides mechanically lodged among its crystals by washing with brine cooled down to 0° C. by an ingenious application of what might be called the waste cold. This brine afterward serves toward the decomposition of the next lot of sulphates of aluminum and iron, so that nothing is lost. The crystals after washing are freed from moisture in a centrifugal machine, and are then fit for any purpose to which Glauber's salt is applicable. I have lately learnt from the inventor that he has succeeded, at a very trifling cost, in using this salt as a raw material for the production of caustic soda.

We return now to the mother-liquor—a solution of chlorides of aluminum and iron. One of the guiding principles of industrial chemistry is that every result of a decomposition should be brought out in a merchantable form. How far can this be carried out in the present instance? To obtain chloride of aluminum in a hydrated state a very costly and circuitous process has hitherto been employed. The commercial sulphate of alumina—so called cake-alum—is dissolved, precipitated with an alkaline carbonate, and the precipitate re-dissolved in hydrochloric acid. Hence its price has naturally been greater than that of the sulphate, and the latter salt has therefore been employed in preference. There is, however, one class of purposes for which the chloride of aluminum would at equal prices be preferred to the sulphate. Several years back it was very justly remarked by Mr. Crookes that the settlement of the sewage question must to a great extent turn upon cheap soluble alumina. The power of alumina in such states to seize upon organic matter not merely when suspended, but when dissolved in water, and to precipitate it in combinations of which "lake-colors" are the most familiar type, is well known to practical men. How many of the everyday operations of the dyer and the color maker entirely or mainly depend upon this very power I need not stay to point out.

That the action of aluminous salts upon fæcal matter is closely analogous to their behavior with tinctorial principles must be admitted when we see that, according to the recent official investigations of Dr. R. Angus Smith, the "albuminoid ammonia," or organic nitrogen, in the effluent waters from the Aylesbury sewage works, was found as low as 0·024 grain per gallon—a little more than one-fifth of the limit proposed as admissible by the late Royal Rivers Pollution Commission.

Yet so long as the soluble salts of alumina were high in price, results such as the above, however interesting from a theoretical point of view, were of little value to the practical sanitarian. Soluble alumina, in the form of sulphate, has indeed experienced a remarkable reduction in price during the last eight years; but, thanks to M. Fournier, its future cost in the state of chloride will be even lower than it is at present. Nor should it be overlooked that, other things being equal, chlorides are decidedly preferable to sulphates for sanitary purposes.

The aluminum chloride prepared as described above is not applicable to dyeing and to the destruction of vegetable matter mingled with wool, on account of its contamination with iron, an impurity which in the treatment of sewage and night soil is by no means objectionable. But for the preparation of a pure aluminum chloride M Fournier proposes to use the ordinary cake-alum as a starting point. This salt is dissolved, mixed with a proper proportion of brine, and refrigerated as described above. The results are Glauber's salts and aluminum chloride fit for the so-called "carbonization" of wool, and of course cheaper than that obtained in the ordinary manner.

Another French inventor, M. Pechiney, of Salindre, in order to utilize the "sel mixte" of the salt works on the Mediterranean coast, a mixture of common salt and of magnesium sulphate, exposes the lyes by means of Carré's ice machine, to a temperature of —6° C. The results are analogous to those obtained in the Fournier process; Glauber's salt is deposited in a fine crystalline mass, while chloride of magnesium—an article now largely consumed for weighting textile fabrics—remains in solution.

M. Pechiney proposes a very ingenious process for converting this hydrated sodium sulphate into the anhydrous salt known in the trade as salt cake. About 1,500 kilos of the crystalline paste, previously drained, are placed in a wooden cistern fitted with an agitator, and dissolved in a little of the mother liquor with the aid of steam introduced by a copper worm. When the whole is dissolved, 250 kilos of common salt are added. An exchange now takes place; the salt gradually dissolves, and the sulphate is deposited in its stead, but in an anhydrous condition. This sediment is then transferred to a filtering vat with a double perforated bottom, and allowed to drain. It is thus obtained free from all foreign matter, save about 5 per cent. of water and 0·5 of common salt.

It is highly probable that the processes here described may point the way to further applications of low temperatures in the chemical arts.—*J. W. Slater, in Jour. of Science.*

## AUTOMATIC APPARATUS FOR WASHING BONE-BLACK.

THE automatic washing apparatus for bone-black, represented in our illustration, Figs. 1 and 2, consists of a sheet-iron channel with double bottom resting on two supports, S. The upper bottom is formed by the plates, $B_1$, $B_2$, $B_3$, which are not perforated and are strongly riveted, and of the perforated plates, C, $C_1$, $C_2$, $C_3$, $C_4$, which can be easily lifted up. A copper-tube, U, furnished with two taps, H and $H_1$, leads water into the transverse tubes, R, $R_1$, $R_2$, $R_3$, $R_4$, which are closed by the stoppers, A, and contain three series of openings.

The bone-black which has to be washed is brought into the hopper, E, and the tap, $H_1$, is opened; the water streaming upon it through the transverse tube, $R_4$, pushes the bone-black down, while that coming from the tube, $R_3$, works in an opposite direction. Thus the downward movement of the bone black is slackened and the water flows through the openings of the bottom, $C_4$, upon the lower bottom of the apparatus; one part of the dirt thus becomes separated from the bone-black, while the latter continues to move downward and arrives finally at the perforated plate, $C_3$, where it is subjected to the action of the water streaming from the transverse tube, $R_3$. From here the mass moves still more downward and finally falls into the channel, K, mixed with a small quantity of water. The water flows off from the double bottom through a tube, *s*, and streams into a series of reservoirs, K, where it leaves the remainder of the bone-black, which it still may contain.

## MANUFACTURE OF AMMONIA BY MEANS OF NITROGEN CONTAINED IN THE AIR.

By J. P. RICKMANN.

IT is well known that Mr. Maxwell Lyte has proposed to manufacture ammonia by conducting nitrogen and steam into a mixture of potassium and antimony. Mr. Swindells, for the same purpose, conducts the atmospheric air and steam over incandescent coke.

Mr. Rickmann's process is similar to that of Mr. Swindells, and consists in leading a mixture of five volumes of air and twelve volumes of steam over incandescent coal or coke, heated to from 1,022° to 1,112° F. The apparatus employed for this purpose and illustrated in the figure is composed of a number of retorts, A, conveniently connected with the stove, B. These retorts are made of earthenware or of iron, at their lower extremity is a partition closed by a movable grate, *r* (designed to retain the incandescent coke) and a door, D, which is air tight. This door can be opened when the grates have to be removed or the retorts have to be cleaned. The apparatus is filled through the opening, E.

When the retorts are heated to 1,022° the valves, *f*, are opened and steam is introduced through the tube, H, which is connected with a boiler and which enters the end of the pipe, F, the latter being furnished with side openings, through which atmospheric air is inhaled which becomes mixed with the steam. The quantity of atmospheric air admitted through the openings is regulated by means of a register, *h*, which more or less closes these openings of pipe, F. The mixture of air and steam enters through the grate, *r*, into the heated mass, C; the oxygen of the air and of the steam become combined with the carbon, while the nitrogen of the air is united with the hydrogen of the water, thereby forming ammonia. The ammonia escapes through the pipe, G, and may be condensed by a convenient apparatus.

According to another process the retorts are filled with substances containing carbon, mixed with alkalies or alkaline earths and heated to about 1,832° F., while simply a current of air enters the tube, F. Finally, the apparatus is cooled to 1,022°, and steam or a mixture of steam and air is introduced.

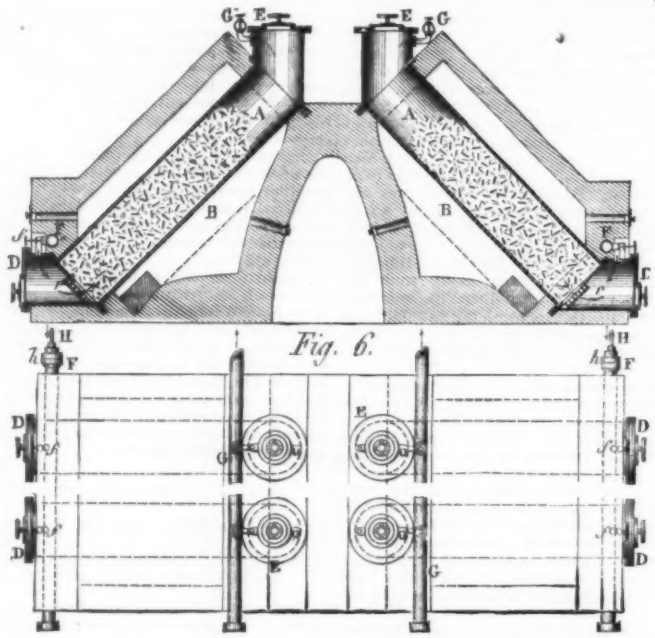


*Fig. 6.*

## MANUFACTURE OF AMMONIA BY MEANS OF NITROGEN CONTAINED IN THE AIR.

## OXALIC ACID IN BEET LEAVES.

By A. MULLER.

THE results of the author's investigations show that the fresh leaves of the sugar beet contain four per cent. oxalic acid, of which one-third is in a soluble form. When it is considered how great are the quantities of these leaves eaten by cattle in countries where the beetroot sugar industry is large, it behooves farmers to be on their guard, as the acid induces inflammation of the mucous coats of the stomach. The pickling of the leaves with chalk is likely to prevent this unpleasantness, the soluble acid being converted into calcium oxalate, which is insoluble in the weak acids of the stomach.

## JUICE OF THE FIG TREE.

By BOUCHUT.

THE milky juice which is found in small quantity in the common fig tree was collected in Provence in the month of April. 5 grammes of the partially coagulated substance, consisting of a sirupy liquid, and a white, sticky, resinous, elastic, aromatic coagulum, were mixed with 60 grammes distilled water, 10 grammes of moist fibrin added, and the mixture kept at a temperature of 50°. In less than twenty-four hours the fibrin was completely digested, leaving a small quantity of white, homogeneous residue. A further quantity of 10 grammes, then 12, then 15, in all 90 grammes of fibrin, were added in the course of a month. Each successive quantity was completely digested in twenty-four hours, and each left a white residue, the composition of which has not been determined. The liquid showed no signs of fermentation or putrefaction.—*Compt. Rend.*

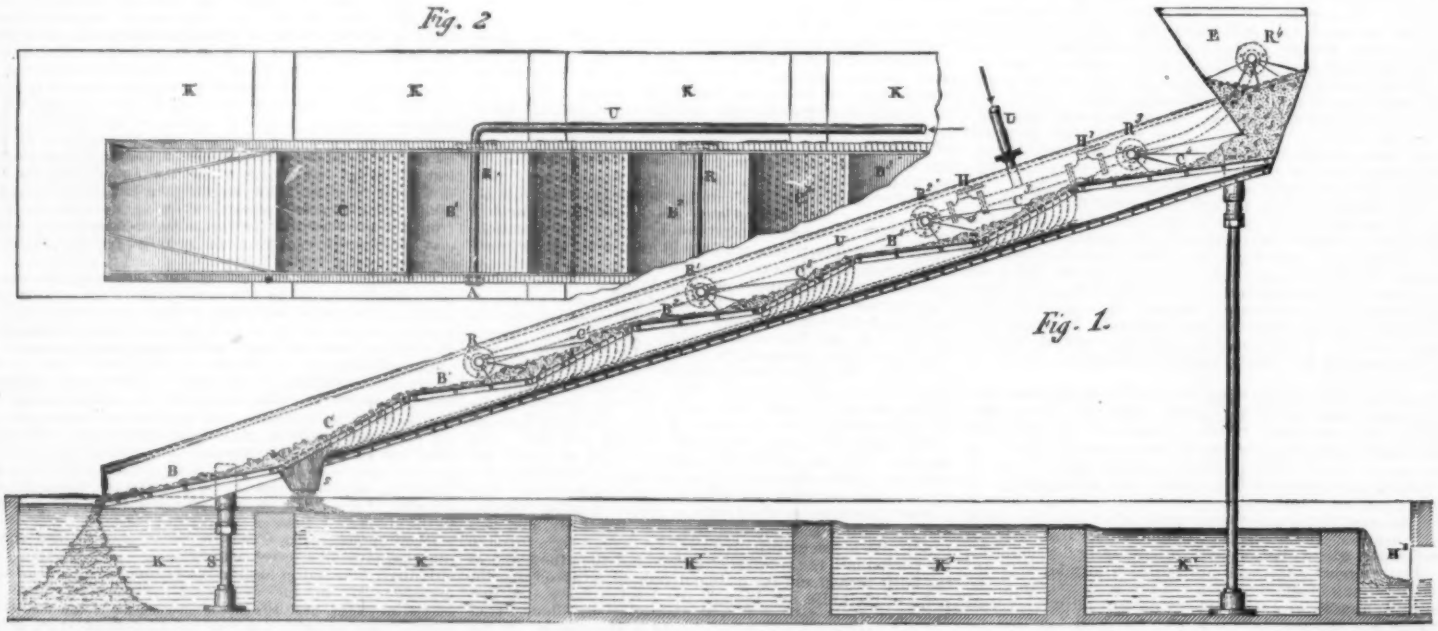
## NEW ARTIFICIAL COCHINEAL.

By L. VIGNON and J. B. BOASSON.

The authors have obtained a series of dye-stuffs, one of which has been isolated in the pure state, and is prepared by the action of diazoamidoazobenzene on β-naphtholsulpho-

*Fig. 2*

*Fig. 1.*



AUTOMATIC APPARATUS FOR WASHING BONE BLACK.

nic acid. It imparts to wool a more beautiful and solid color than cochineal, the shade being more violet the higher the temperature at which the naphtholsulphonic acid has been prepared. This dye-stuff was introduced into the trade some months ago under the name of Ponceau RR.

## PROTECTIVE MIMICRY IN ANIMALS AND PLANTS.

"MIMICRY," says Prof. Mivart, in the current number of the *Contemporary Review*, is a close and striking, yet superficial resemblance borne by some animal or plant, to some, perhaps, very different object. A familiar example of mimicry is seen in the bee and spider orchis, and in clear-winged moths, which may be mistaken for bees. One of the most perfect examples of mimicry is afforded by an insect (of the grasshopper and cricket order) which is called, on account of the appearance it presents, the "walking leaf," since both in form and color its body so closely resembles a leaf that it is most difficult of detection when found among real leaves. Not only moths, but beetles imitate bees. There are also creatures called "bamboo" or "walking sticks," which present a most striking resemblance to twigs of bamboo, and this from the more strange habit they have of hanging with their legs stretched out unsymmetrically, and so more closely resembling the plant. One of the most complete instances of mimicry is that afforded by an Indian butterfly, as to which Mr. Wallace remarks: The most wonderful and undoubted case of protective resemblance in a butterfly that I have ever seen, is that of the common Indian *Kallima inachis*, and its Malayan ally, *K. paralekta*. The upper surface of these is very striking and showy, as they are of a large size, and are adorned with a broad band of rich orange on a deep bluish ground. The under side is very variable in color, so that out of fifty specimens no two can be found exactly alike, but every one of them will be of some shade of ash, or brown, or ocher, such as is found among dead, dry, or decaying leaves. The apex of the upper wing is produced into an acute point, a very common form in the leaves of tropical shrubs and trees, and the lower wings are also produced into a short tail. Between these two points runs a dark curved line exactly representing the midrib of a leaf, and from this radiate on each side a few oblique lines which serve to indicate the lateral veins of the leaf. This resemblance, as close as it is, would be of little use if the habits of the insect did not accord with it. These butterflies frequent dry forests, and fly very swiftly. They were seen to settle on a flower or a green leaf, but were many times lost sight of in a bush or tree of dead leaves. On such occasions they were generally searched for in vain; for, while gazing intently at the very spot where one had disappeared it would often suddenly dart out, and again vanish twenty or fifty yards further on. On one or two occasions the insect was detected reposing, and it could then be seen how completely it assimilates itself to the surrounding leaves. It sits on a nearly upright twig, the wings fitting closely back to back, concealing the antennæ and head, which are drawn up between their bases. The irregular outline of the wings gives exactly the perspective effect of a shriveled leaf. We thus have size, color, form, markings, and habits, all combining together to produce a disguise which may be said to be absolutely perfect; and the protection which it affords is sufficiently indicated by the abundance of the individuals that possess it. But there are facts yet more extraordinary. Some insects which mimic leaves, mimic even the marks made upon leaves by the ravages of other insects, or by mould. As to this Mr. Wallace tells us; One of these creatures (*Cerorylus laceratus*) obtained by myself in Borneo was covered over with foliaceous excrescences of a clear olive-green color so as exactly to resemble a stick grown over by a creeping mass of *Jungermannia*. The dyak who brought it to me assured me it was grown over with moss, although alive, and it was only after a minute examination that I could convince myself that it was not. Among plants we also find cases of mimicry. Thus, some *Euphorbias* which grow in Africa so greatly resemble cacti that it is difficult to believe when they are not in flower that they are not really the plants they so resemble. Another close resemblance exists between *Eucalypti* and *Mimoses* in Australia. Also a certain fern (*Stangerda paradoxa*) closely imitates a Cycad; and, as has been pointed out by Mr. A. W. Bennett, the winged fruits (*Samaræ*) of no less than four genera of Brazilian plants belonging to three distinct natural orders, are alike not only in the form of the wing, but in the very texture and arrangement of the veins, so that dissection is needed to detect the essentially different structures which exist beneath this great external similarity. Besides insects and plants, various fishes, reptiles, birds, and even some beasts, also appear to be unconscious mimics. Thus the pipe fish (*Phyllopteryx eques*) bears curious, long, cutaneous appendages which imitate the forms of sea weed amidst which the fish habitually lives. There is also one kind of bat which mimics the leaves of the tree on whose fruit it feeds, while another kind of bat has the appearance, while at rest, of a large ripe fruit. These resemblances are evidently akin to those so frequently observed to exist between the color of an animal and that of adjacent objects—resemblances which many animals either permanently possess or temporarily assume. Of these instances there are legions: as sandy-colored snakes and lizards of deserts, and green snakes of grass and trees. Actual changes of color to harmonize with surroundings are shown by the ptarmigan, the variable hare, the ermine, the Arctic fox and others, and, most notably of all because most frequently and rapidly, by the chameleon. Mr. Leslie inclosed certain caterpillars of one kind in two boxes, one black and the other white, and he found that the color of the chrysalis in each case harmonized with that of the box. Mr. Robt. Holland also found the cocoons of the emperor moth to be either white or brown according as they were spun on paper, or amid dead grass, or on soil. Mr. K. H. Stebbing has found that the chameleon shrimp has the power of changing from a dark purple color to a glassy transparency. The protective effect of many of these changes is evident, but their action in some cases is problematical, like that of the relations between color and locality.

## THE ANIMAL LIFE OF THE DEEP SEA.

IN regard to the animal life of the deep sea, says Dr. W. B. Carpenter, in the current number of the *Nineteenth Century*, the Challenger researches do not seem likely to yield any new *general result* of striking interest. Our previous work had shown that at a depth of three miles, a pressure of three tons on the square inch, an entire absence of sunlight, and a temperature below 32°, might be sustained by a considerable number and variety of animal types; and this conclusion has been fully confirmed and widely extended. Many specimens have been brought up alive from depths exceeding four miles, at which the pressure was four tons on the square inch, considerably exceeding that exerted by the hydraulic presses used for packing Manchester goods. Even the "protected" thermometers specially constructed for deep sea sounding were frequently crushed; and a sealed glass tube containing air, having been lowered (within a copper case) to a depth of 2,000 fathoms, was reduced to a fine powder almost like snow, by what Sir Wyville Thomson ingeniously characterized as an *implosion*; the pressure having been apparently resisted until it could no longer be borne, and the whole having been then disintegrated at the same moment. The *rationale* of the resistance afforded by soft-bodied animals to a pressure which thus affects hard glass, is simply that they contain no air, but consist of solids and liquids only; and that since their constituent parts are not subject to more than a very trifling change of bulk, while the equality of the pressure in every direction will prevent any change in their form, there is really nothing to interfere with the ordinary performance of their vital functions. The entire absence of solar light, which constitutes another most important peculiarity in the conditions of deep sea life, would seem at first sight to be an absolute bar to its maintenance. Experimental evidence has not yet been obtained of the direct penetration of the solar rays to more than 100 fathoms, but as I dredged slow-growing red calcareous algæ (true *Corallines*) in the Mediterranean at a depth of 150 fathoms, the actinic, if not the luminous rays, must probably penetrate to that range. Below what Edward Forbes termed the coralline zone, it would seem impossible that any other type of vegetable life can be sustained than such as have the capacity of the fungi for growing in the dark, living, like them, upon material supplied by the decomposition of organic compounds. Such lowly plants have been found by Prof. P. M. Duncan in corals dredged from more than 1,000 fathoms' depth. Upon what then do deep sea animals feed? The Challengers researches have thrown a new light on this question, by showing that the animals of the deep sea are largely dependent for their food upon the minute organisms and the *débris* of the larger ones, which are continually falling to the bottom from the upper waters. The entire absence of sunlight on the deep sea bottom seems to have the same effect as the darkness of caves, in reducing to a rudimentary condition the eyes of such of their inhabitants as fish and crustacea, which ordinarily enjoy visual power; and many of these are provided with enormously long and delicate feelers or hairs, in order that they may feel their way about with these, just as a blind man does with his stick. But other deep sea animals have enormously large eyes, enabling them to make the best of the little light there is in the depths, which is probably derived (as suggested in the report of the Porcupine dredgings) from the *phosphorescence* emitted by many deep sea animals, especially a certain kind of zoophytes. "It seems certain," says Mr. Moseley, "that the deep sea must be lighted here and there by greater or smaller patches of luminous alcyonarians, with wide intervals, probably, of total darkness intervening; and very possibly the animals with eyes congregate around these sources of light." It is remarkable that with such poverty of light there should be such richness of *color* among deep sea animals. Although most deep sea fish are of a dull black color, and some white as if bleached, deep sea crustaceans, echinoderms, and zoophytes, usually exhibit more color than the corresponding forms that inhabit shallow water. Thus the deep sea shrimps, which were obtained in very great abundance, were commonly of an intensely bright scarlet; deep sea holothurians are often of a deep purple; and many deep sea corals have their soft structures tinged with a madder coloring matter resembling that which occurs in surface-swimming jelly fish.

## THE MINOR USES OF FISH PRODUCTS.

SOME of the minor uses to which parts of fish are put are quite curious. Thus, in India, the jawbone of the boalee fish (*Silurus boalis*) is employed by the natives about Dacca for carding; the teeth being small, recurved, and closely set, act as a fine comb for carding purposes, in removing the loose and coarse fibers and all extraneous matters from the cotton wool. The serrated spine of the ray-fish is used by the Indians of the Amazon to arm their arrows. Sharks' teeth are used in arming weapons, and the teeth of these, as well as those of other fish, as trinkets. The jaws of the sleeper-shark (*Somniosus brevipinna*) are used for headdresses by the North American Indians. Fish bones are used by the Indians and Eskimo in making implements; sharks' vertebræ for canes; the bones of whales for weapons. Those of sharks and skates are employed in Japan in the manufacture of imitation tortoise-shell. Among the islands of the Corean Archipelago the dried spiral eggs of a species of skate are used as rattles for children. At the Vienna International Exhibition the scales of the captain-fish (*Heterotis*), from Senegal, were shown, for making fish-glue to stiffen and glaze ribbons. The Royal University of Norway sent to the Smithsonian Institution, in 1875, a diadem made from fish scales and eyes; and at the Paris Exhibition of 1878 two Swedish exhibitors showed flowers and ornaments made of fish scales. At one time ornaments made of fish scales, for ladies, were largely sold at the Crystal Palace, London. At Newark, N. J., large fish scales have been industrially employed for some time. The fresh scales are steeped for twenty-four hours in a solution of marine salt in order to clean them. They then undergo five or six washings in distilled water, which is renewed every three or four hours. Each scale is then separately dried with a clean cloth, lightly pressed, and left to dry. Finally, they are macerated for an hour in alcohol, and rubbed dry. They then appear like mother-of-pearl, and of a firm and elastic consistence. They are worked up, either plain or colored, for making artificial flowers, marquetry articles, and other fancy work. The Chinese have a mode of grinding up fish scales, and using the powder as a dry pigment to give a brilliancy to parts of pictures. Fish scales are composed of alternate layers of membranous laminæ and phosphate of lime, to which they owe their brilliancy. Perhaps the enamel or nacreous coverings of these objects generally is capable of being employed still more largely in the arts; it appears to be *sui generis*, and seems hitherto to have escaped the scrutiny of organic chemistry. As well known, the perfectly white solution of the scales of the bleak (*Leuciscus alburnus*), a fish indigenous to the rivers of France, is now largely used for the manufacture of artificial pearls. The solution or "guanine" is a mucus which lubricates the scales of the fish. It coagulates by heat to a thick, white deposit, and is obtained by carefully scraping the fish over a shallow tub containing fresh water. Care is taken not to scale the back or dorsal part, as the scales there are yellow, while it is only the white scales that possess value. The material is received on a horse-hair sieve. The first water, mixed with a little blood, is thrown away. The scales are then washed and pressed, when the essence or mucus sinks to the bottom of the tub, and appears as a very brilliant blue-white oily mass. It takes 40,000 fish to furnish two pounds of the material. The fishermen seal it in tin boxes with ammonia, and in this condition send it to Paris. If a drop of the essence be taken up by a straw, and allowed to fall upon water, it floats, giving forth a most brilliant play of colors. Glass bulbs, in the shape of pearls, lined with this substance, imitate the real gems with remarkable closeness. The swimming-bladder of a fish (*Argentina sphyræna*), inhabiting the Mediterranean Sea, also abounds in the silvery substance so remarkable in fishes, and is likewise employed to form artificial pearls.

## THIRTY-EIGHTH YEAR OF A FARM WITHOUT STABLE MANURE.

By STECHER.

THIS is the third decennial report of the farm of Wingendorf, conducted by the author since 1840 on the principle of keeping no cattle and not using any stable manure. Since last report the property had passed into the hands of the government, which, on the representation of the leading agriculturists of the district, continued the experiment under the care of the author, and it was made auxiliary to the State farm of Bräunsdorf for purposes of comparison; the latter farm was considered very fertile. This arrangement allowed the author to compare results very closely, as the two farms were treated exactly alike except in the matter of the manure.

In the five years, 1873–1877, the rye crop at Wingendorf exceeded that at Bräunsdorf by an average of 46½ kilos per hectare, and the oats 11½ kilos per hectare, the straw being as abundant in one as in the other. Potatoes were not so successful, showing a deficiency of 46·47 hectoliters per hectare, while clover and flax have failed for many years, on which account a longer interval between the cultivation of these crops has been decided on.

The climate, soil, and situation of the two stations are very similar, yet at Wingendorf the crops of clover yielded scarcely twenty per cent. of a full crop; the grasses sown with the clover suffered equally; the seeds germinated well enough, and promised a good crop in April, but in May and June they failed.

An examination of the manures put on the farm showed that in the ten years from 1858–1867 there were 7,786·55 kilos; and from 1868–1877, 3,580·57 kilos more phosphoric acid put into the ground than was taken out of it. The large quantity of this class of manure was proved to have been unnecessary by the results of the last ten years, when the yield was so satisfactory without further additions of phosphates.

During the first ten years 2,861·25 kilos, and in the last 943·3 kilos, more nitrogen was removed from the soil than had been added. The author considers the excess was in part drawn from the atmosphere. Of potash salts in both periods considerably more was taken off the farm, respectively, 4,641·5 kilos and 3,837·5 kilos than had been added to it. Analysis showed, however, that the soil was very rich in potassium. To secure its solubility a large quantity of lime manure was required, which was very liberally used, the first ten years showing an excess of 13,658·9 kilos, the second ten years 7,898·35 kilos over and above the quantity of lime taken off the farm.

What has been the cause of the failure of the clover, what properties are possessed by the stable manure which is absent from the phosphoric, nitrogenous, potash, and lime manures, the author cannot explain. the condition and treatment of both farms being so exactly similar that no practical farmer could discern any difference; the only explanation that can be given being a supposition that the farm has been attacked with the clover sickness, which sometimes attends clover fields where this crop is grown for the sake of seed only.—*Bied. Centr.*

## MANURE EXPERIMENTS WITH RYE, WHEAT, AND OATS.

By A. PAGEL and H. MEYER.

THE reluctance of small farmers to employ artificial manures is considerable, except in the neighborhood of large farms, where example leads to their partial use. The authors instituted the following experiments, believing that strong efforts should be made to overcome this reluctance.

The first experiment was to ascertain if it would pay better to employ a large or a small quantity of manure; four spaces of one hundred and forty square meters were carefully tilled and prepared exactly in the same way; one was manured with sheep's dung, the other with six hundred kilos of bone meal; the third with three hundred kilos of bone meal; and the fourth, four hundred kilos superphosphate.

The tabulated results show that the employment of the large quantity of bone meal yielded the largest crop, but the three hundred kilo plot paid the best interest on the capital expended.

The second experiment was to ascertain if the employment of larger or smaller quantities of superphosphate after the bone meal of the preceding year paid better interest on the capital employed; and at the same time trials were made as to whether sodium nitrate when used should be dug in or used as top dressing. The experiments prove to the authors' satisfaction that the use of four hundred kilos of superphosphate per hectare is more profitable than two hundred kilos, and that the employment of sodium nitrate is more successful as top dressing than when dug in or sown with the seed; in the latter case a considerable amount of nitrogen is lost by sinking into the ground before the plants are ready to assimilate it.

The third series of experiments was made to verify the effects of artificial manures used with stable dung. The same course of treatment was pursued, and the conclusion arrived at was that the use of the artificial manure increased the produce considerably.

## SYMPHYTUM ASPERRIMUM AS A FODDER.

By E. WILDT and OTHERS.

THIS plant, which belongs to the family *Boragineæ*, is shown to be of great value as a cattle fodder, and as it grows rapidly and gives a large produce, it would repay extensive cultivation. Wildt's analysis of the dried plant gave per cent.: protein substances, 22·37; fiber, 13·24; fat, 3·06; non-nitrogenous extractive matter, 43·04; ash, 18·29; phosphoric acid, 1·62; potash, 7·87; lime, 3·74. A previous analysis by Voelcker showed 23·37 per cent. protein sub-

stance in the leaves, and 13·06 in the stem; non-nitrogenous matter, 54·49 and 72·40; ash, 17·74 and 14·45 in the leaves and stem respectively. Its properties, and the method followed in its cultivation, are also described.—*Bied. Centr.*

## RED CLOVER

By G. HABERLANDT.

EVERY farmer who raises red clover for the sake of the seed is aware of the uncertainty of its produce. The quality of the crop frequently suffers from the unequal ripening of the seeds, and this in a far greater degree than is the case with other field crops. Darwin's researches have shown clover to be one of those plants whose fructification depends on the visits of insects. The florets of any individual head of blossom are not all at one time in a fit state to profit by the visit of those insects, the lower florets expanding first, the upper later, and when these are in full bloom the lower have decayed, or at least are on their way to decay. When the crown of the stalk has bloomed the florets are weakly and unattractive to insects.

The author's researches confirm this view. A certain number of the ripe flower heads, all grown under precisely similar conditions, were examined as to the proportion of fruitful and sterile florets, and it was found that in the upper portion the fruitful seeds predominated; whilst the reverse was the case in the under portion of the flower head. Some seeds were barren in the upper florets, but they were too few to affect the proportion.

Under favorable circumstances the greater part of the florets would be fructified, but those circumstances rarely occur, and for a rarely successful crop of seed, a vigorous and quick bloom, an active visitation of insects is necessary; whilst bad results are to be expected from dull, rainy weather, which retards blossoming, and is unfavorable to insect life. The author suggests the encouragement of bees about clover farms, but can propose no other remedy for the unequal blooming of the flowers than a careful selection of the seed.—*Bied. Centr.*

## ARTIFICAL FRUITING OF TREES.

A CANADA correspondent of the *Rural New Yorker*, date and place not specified, writes as follows to that journal, under the above heading:

A tree or plant may be made more fruitful in three different ways:

1. Extra food and cultivation will induce fruitfulness by supplying a surplus of alburnum, which changes what would otherwise be leaf buds into fruit buds. Everybody is supposed to understand this method, and it needs no comment from me.

2. When the vitality of a tree is injured, it will immediately make an effort to reproduce itself by seed. Of this method there are many minor forms or variations. Thus, greenhouse men cramp the roots of their plants in small pots to produce an extra-large number of flowers; orchardists sometimes bore holes in the trunks of trees that are making a strong growth of wood but do not produce fruit; nails are driven into the trunks, and root-pruning by deep cultivation is also practiced for the purpose of forcing trees to fruit; all of which will be successful if done at the proper time; but if continued too long or employed too freely, they will ultimately destroy the tree. When a tree or plant receives an injury shortly after the young shoots have commenced to grow, the growth will be stopped while there is still a quantity of crude and prepared sap in the body of the tree and branches. There is thus a surplus which will change leaf buds into fruit buds. As unusual example of this I saw some years ago. Mice had girdled an apple tree in June, and, of course gnawed all the new wood completely off. The growth was stopped, but the tree perfected its fruit, and was alive the following spring, the fruit buds partially opened, but there was not a leaf bud to be seen. This tree must have received a limited quantity of sap through the body of the trunk—there was no bark whatever.

3. This method is the principal one we have to deal with, and consists in a partial stoppage of the alburnum from being deposited as new wood, so that the surplus thus formed may be diverted to forming fruit buds. After the bulk of the crude sap has ascended into the leaves and been assimilated or changed into alburnum, it is then distributed into the different parts of the tree, a portion to form new wood, a portion to support and mature the fruit, "if there should be any," and the remainder, "if any," to form new fruit buds. Now where all, or nearly all, this prepared sap is taken to form new wood, there will be no fruit, but if we by any means prevent a portion of this sap from being deposited as new wood, there will be a surplus which will force fruit buds into existence. These means must be used when, or shortly before, the greatest amount of alburnum is being deposited, and shortly before the proper time for fruit buds to form, or else we shall have nothing but a plentiful crop of suckers, latent leaf buds being pushed into shoots.

The minor forms or variations of this method, that are most successful and most generally used here, are binding a cord or wire tightly around the branch or trunk of the tree we wish to fruit; Mr. Spaulding's method of girdling, "but not disbarking," simply cutting through the bark around the tree, or branch "sometimes more than once" just below the point you wish to be fruitful; and pruning and cutting back the young shoots. These will all answer the purpose, and where properly done will never injure the tree. One orchard, now eighty years old, after having been girdled or bound more or less for 30 years, shows no ill effects from the usage. No doubt some of the trees have died, but, if from this usage, their case was something like that of the poor colored woman down South, who died from smoking at the age of 105.

Yesterday I examined a peculiar phase of artificial fruiting. A Bartlett pear in the orchard of M. W. Carmichael had been pruned when the young shoots had made a few inches growth. Very hot weather had then set in for some days; the pruning had stopped the growth of the shoots; the excessive heat had forced the latent buds not only into fruit buds, but into blossoms, and there are now two crops of fruit on the single tree—pears nearly ripe and half-grown.

Disbarking will not injure a tree if done just as the greatest amount of alburnum is being deposited, unless this new wood is scraped, or dried by excessive heat. I have seen three trees completely disbarked. The first was in the orchard of Mr. John Ferguson, and was a scabby gnarly tree that had never made any growth. The bark was carefully taken off from the roots to the small branches; in a couple of hours it was covered by a sap-like froth, and by the next morning this had become more firm. In three days I saw it again, and the new bark was quite firm. Next year it had a crop of apples, and made a good growth, and is now as healthy a tree as any in the orchard. The next tree was one that grew in a fence corner, and was disbarked by using a spade. It also lived, but wherever the spade touched there was a dead spot. The third was disbarked in the morning of a very hot day. No bark formed, and it dried up, but the branches lived for some time.

Where incisions are made in the bark they should be made immediately below the part we wish to fruit, as it is the prepared sap we wish to divert, not the crude. I think Mr. Parsons is mistaken in claiming his method as the most logical and scientific, as the girdling is certainly the most successful. If the idea in his method is to divert the crude sap from forming wood, it is a mistake, as it will simply go into other branches or push latent leaf buds into young shoots or suckers. If the idea is to prevent the alburnum from ascending to the young shoots, then all will have to be served alike, which would be a great deal of trouble, and even then would sometimes fail to produce the desired effect, but the young branches above the incisions would fruit.

I have not tried fruiting grapevines or anything that fruits on the new wood, but some of my neighbors say that it can be done in the same way as apples or pears.

## BOTANY OF THE KURAM VALLEY.

IN the winter of 1878 Surgeon-Major Aitchison accompanied our troops, under General Sir Frederick Roberts' command, during the advance of the Kuram field force into the Kuram Valley, at the taking of the Peiwar-kotal, and he proposed that a botanist be allowed to accompany the column in the contemplated advance on Cabul. Surgeon-Major Aitchison was himself attached to the force as botanist in April, 1879, and collections were made along the left bank of the Kuram River, from Thall to Peiwar-kotal. The collection, consisting of over 15,000 specimens, was arranged and an account laid before the Linnean Society. The memoir opens with an outline of the geography of the country traversed. Thall is about 2,500 feet, Kuram is nearly 4 800, and the pass of the Peiwar is 8,500 over sea level. Of the peaks about Peiwar that of Karaia is 15,400 feet, while that of Sikuram is 15,600 in height. Between Thall and Badish-khel the aspect is not, for a botanist, promising. In the whole district there is no cultivation without irrigation. The Kuram plains, formed of immense deposits of mountain *débris*, are in summer totally devoid of water, and in winter are covered with snow. Along the base of the Sufed Koh range numerous valleys debouch upon the plain; these are extremely fertile, and the field cultivation reminds one of the best parts of Cashmere. The Oriental plane, the walnut, and the amlok grow to a great size; orchards are common, and contain the apple, apricot, plum, quince, and grape. The soil yields two crops during the year, the first being barley, wheat, and clover, the second rice, maize, and one of the millets. Cotton is only grown in the more southern parts of the district to the east of Kuram. Tobacco and opium are garden produce. The vegetables cultivated are numerous. On the slopes of the mountains the limit of forest is usually reached at 11,000 feet, in some favored spots single trees of *Pinus excelsa* and *Abies webbiana* not unfrequently exist up to 12,000. A dense forest occupies the ridges of the Peiwar-kotal, consisting chiefly of deodar, with *Abies smithiana* and *Pinus excelsa*. On its spurs this forest growth completely disappears at 11,000 feet, and is replaced with flat masses of the common juniper. This disappeared at 12,000 feet, leaving the summits of the peak perfectly bare, unless where a bowlder afforded shelter to some Alpine plant. The forests were both extensive and fine, containing splendid timber. The natives do not employ timber of any size in their buildings, and, as a rule, scarcely ever cut down a large tree. Throughout the forests few, if any, trees are to be found partially burnt, presenting in this a great contrast to the forests of Cashmere. Some of the exceptionally large trees met with measured as follows: Plane, circumference 33 feet; walnut, 17 feet; deodar, 21 feet; celtis, 16 feet; oak, 13 feet; a variety of the black poplar, 10 feet 6 inches. No oil seeds are cultivated; for light, pine splinters are used, and, in lieu of vegetable oils for food, the melted fat of the tail of the large-tailed sheep is consumed. A very handsome new clematis, with flowers of a pale lemon color, and from 3 inches to 5 inches in diameter, called after General Roberts, and a new yellow rose, are among the many new species found and described.—*London Times.*

## INSECTICIDES.

AT the session of the American Association, Mr. R. J. Cook, of Lansing, Mich., discussed two new uses of important insecticides. As is well known, there is scarcely a worse pest to the pomologist than the codlin moth, *Carpocapa pomonella*, Linn. Many thousand dollars' worth of our fruit is consumed annually to feed this destroyer. The mischief done is augmented from the fact that the best preventive hitherto known has not been effective until the insect destroyer had wrought its evil work. We have known no way to destroy the moths, but could only capture and destroy the larvæ after the apples were eaten. Last winter I learned from Mr. J. S. Woodward, of Lockport, New York, that trees thoroughly treated with Paris green, about the 20th of May, bore fruit which was wholly exempt from the ravages of the "apple worm." Acting upon this suggestion, I sprayed some apple trees the 25th of May, and again the 20th of June; but I used London purple, arsenite of lime, which is nearly as insoluble in water as Paris green. I used one pound of the poison to one hundred gallons of water. The trees were loaded with fruit, and their fruit has been seriously injured by codlin moth larvæ whenever they have borne fruit during previous years. Careful examination made August 20 of this year disclosed no injured apple A few apples showed signs of the previous work of the larvæ, but as no burrow extended for more than one-fourth of an inch, no harm was done. Other apple trees a few rods distant, to which the poisoned liquid was not applied, are bearing fruit; one-fourth to one-half of it is wormy. From the slight amount of the poison applied to each tree, not more than one-third of an ounce, the cost of the remedy is light; neither do I apprehend danger from its use at so early a date. To one portion of the tree I applied the poison in a greater quantity than is necessary, so that some of the foliage was killed. On the 19th of August I cut from the trees which had received the concentrated mixture one hundred of the blossom ends, the part where the poison would be most readily held, and submitted them to Professor Kedzie for chemical analysis. No trace of the poison was found. The fact that this poison is now extensively used in the West to destroy the canker worm, and with no sign of evil, sustains the argument in favor of its harmless nature so far as the fruit is concerned. The danger of poisoning the soil is a matter for the chemist to decide. If future experience sustains the conclusions as to the efficiency of this remedy in case of the "apple worm," it will be an important discovery. Up to the present time there has been no satisfactory method of fighting such pests as the cabbage maggot and other insects of the same genus, and the squash borer. The late Dr. Walsh recommended hot water; this has proved but partially successful. From the value of bisulphide of carbon as a destroyer of museum pests, and from its efficacy in destroying the *phylloxera* of Europe, I was led to try its power in overcoming our subterranean insect pests. Both my pupils and myself tried experiments with the happiest results. A small hole was made in the earth, near the main root of the plant, by use of a walking stick, and about fifteen cubic centimeters of the liquid was poured in, and the hole quickly filled with earth, which was pressed down with the foot. In every case the insects were killed without injury to the plants. I believe this liquid promises satisfactory results in fighting the above-mentioned insects, the peach borer, and other insects which attack the roots of our cultivated plants. We must remember, of course, that this liquid is very volatile and the vapor exceedingly explosive.

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